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HOME & FARM WATER SUPPLY MANUAL

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FOREWORD

This manual, dedicated to those who have a sincere desire to learn about Water Pumps, Water Systems, and Conditioned Water, has been revised three times since its need was determined in 1950. Countless thousands of copies have been used by pump men, students, teachers, county agents and others.

Revision of this Manual, therefore, was undertaken in a spirit of sincere appreciation for the widespread support given to the earlier editions.

The information contained is slanted towards basic fundamentals as well as selection and application. It presents data, where possible, in the form of pictures, tables and charts. It is intended for study and lasting reference value.

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WATER IS AN ELEMENTARY NEED

A description of what the world would be like without water is not as difficult as it seems, for one simple statement would be sufficient. There would be no world. Water is truly life's most vital need. Man has searched for it, fought for it, and sometimes died for it throughout the long centuries of his existence, from the time of creation to the present day, for no living organism can exist long without it. We can survive a considerable longer period of time without food or shelter than it is possible to live without water.

Water is always present. It makes up approximately 80% of all living matter. The human body contains approximately 12 gallons of water. The human brain contains about 87% water, the blood 90%, and our bones about 50%.

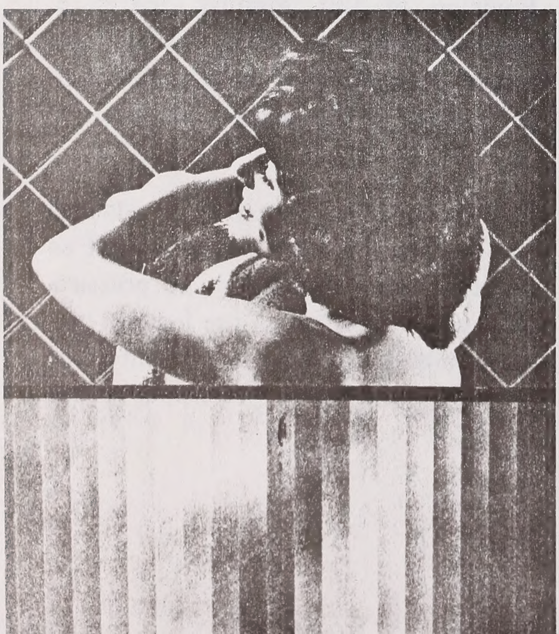
The growth and development of all things depends on an ample supply of water — "ONE OF NATURE'S GREATEST GIFTS."

CONVENIENCE OF RUNNING WATER IN THE HOME

A. Suburban and Farm Home Use

The home and farm with an abundant supply of water under pressure has a short cut to better health, more profit, extra leisure and better living.

A farm wife once kept a record of her hours of water pail drudgery. The well was 15 feet from the house, 150 feet from the barn. She estimated she walked 124½ miles a year — much of it in bad weather — carrying a total of 62.4 tons of water. She spent 769 hours and 54 minutes in pumping and carrying water. That means 96 average 8-hour work days a year were spent just providing water. Think of all the more pleasant ways she might have enjoyed those 96 days!



Surveys have been made by disinterested parties and have shown that the average American non-farm or suburban home will use from 65,000 to 75,000 gallons of water per year. This would require approximately 240 hours labor to operate the hand pump during the year, not to mention the back-breaking labor required to carry the water.

The following are some uses of water in the home:

1) **Bathing** — running water promotes health and cleanliness. The modern bathroom with tub-shower bath, toilet and lavatory promotes better health and is more convenient. The modern bathroom is enjoyed more by the entire family than any other convenience that running water makes possible.

2) **Fire Protection** — a ready supply of running water has often meant the difference between a harmless blaze and a destructive fire.

3) **Dish Washing** — there is no substitute for a supply of clean hot water when washing dishes. The advantage of this of course can be further improved by the use of an automatic dish washer, which would not be possible without running water.

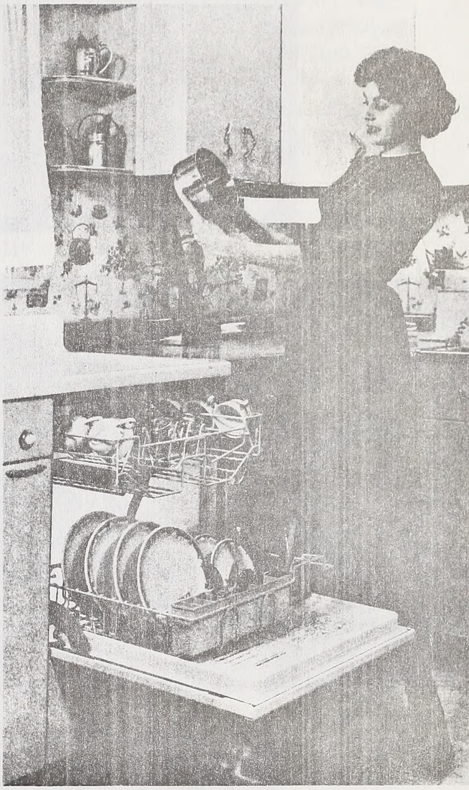
4) **Laundry** — running water ends the need to carry pails of water on wash day and means cleaner clothes and less work for mother. It helps take the "blue" away from Monday.

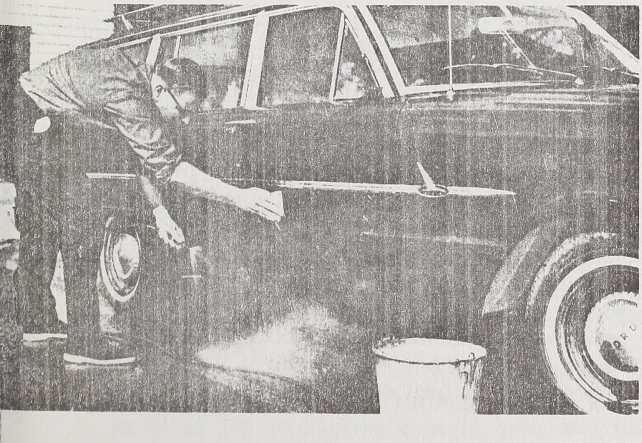
5) **Cooking** — cooking and canning are easier when there is a ready supply of fresh pure water. The convenience of a garbage disposal would not be possible without running water.

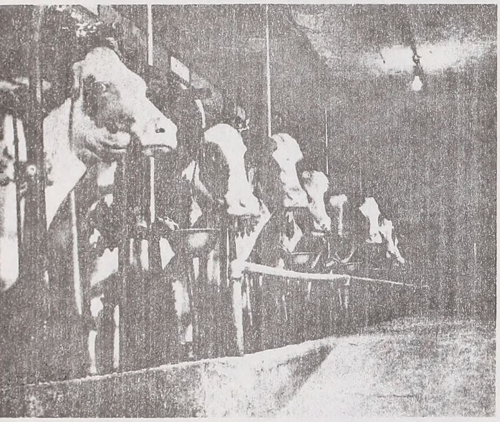
6) **Lawn Sprinkling** — keeps grass fresh and green regardless of lack of rain or of legal restrictions against the use of water from a central system.

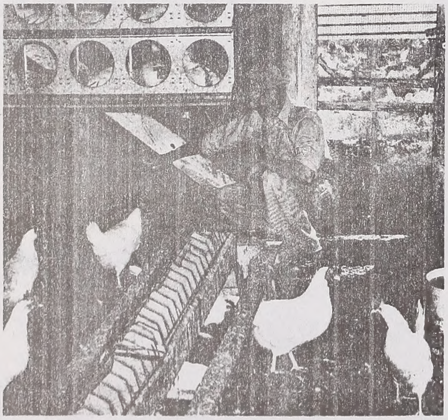
7) **Car Washing** — so much easier with running water.

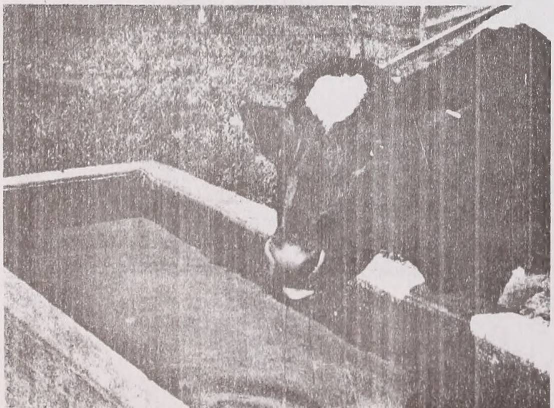
A good adequate capacity water system will supply water for the average home use for from 2 to 4 cents per day. Running water is truly a labor saver, giving more time for leisure or other productive effort. It promotes better living and protected living. Children born and raised in houses with an adequate water supply have a much lower mortality rate than in homes where outdoor plumbing is found.











PRODUCTIVE USES OF WATER

In addition to providing better health and more leisure and convenience in our daily living, water has many productive uses which increases profits through increased production. These extra profits more than pay for the installation of a water system.

A) Home and Garden

The home and farm vegetable garden will yield 50% more production and a better quality vegetable with a garden hydrant and a rotating sprinkler. During the growing season plants can be supplied with water when needed to increase production and improve quality.

B) Milk Production

Tests and surveys have proved that when water is available at all times to dairy cows, milk production has increased from 10 to 22%. As milk is 87% water, a cow consumes 3½ to 4 pounds of water for every pound of milk produced. Cows with access to water consume 15 to 20% more water than cows watered twice daily. Water is essential for sanitation about the milk house and the milking parlor.

C) Egg Production

Egg production has been increased 8 to 10% after automatic poultry waterers were installed in poultry houses. In addition to more production, the eggs are better quality and larger, resulting in a better grade of egg that will sell at a premium price. Half of a bird's body and two-thirds of an egg are water. A shortage of water will cause a drop in egg production faster than a shortage in feed. Winter egg production has been maintained to 70-80% of summer months when hens have access to water at 45 degrees minimum temperature.

D) Meat Production

Here again, production has been increased from 10-20%. This applies to both beef and pork. Animals with clean fresh water available at all times put on more weight. Numerous bulletins issued by the U. S. Dept. of Agriculture, as well as reports from the Depts. of Agriculture of various states and state agricultural colleges, verify these increased production figures. For example, water makes up 50% of the body composition of a hog. A 250 pound animal consuming 1.9 gallons of water daily should result in 1.8 pound weight gain per day. Removing the chill from freezing water increases the daily gain of pigs 6% and improves their feed efficiency.

WHY ADEQUATE SUPPLY IS NECESSARY

A) General

When one turns on a water tap, they do it for one reason — to get water! To put your water system to work on a full-time basis and realize the utmost from the productive uses and labor saving conveniences of running water under pressure, you must have adequate capacity. Your water system must have capacity enough to supply you with water at the house, barn, feed lot, poultry house, and vegetable garden — if you live on a farm — and to supply that water at the turn of a tap. A small water system with only enough capacity to supply one or two outlets cannot give you water when and where you want it.

The fact that an adequate capacity water system furnishes fire protection is in itself reason to purchase a water system with a capacity of from 8 to 10 gpm, if the water source is ample.

When the farm or suburban resident returns home after a hard day's work in mid summer he heads for the bathroom for that refreshing bath which will make the evening meal more enjoyable. The adequate capacity water system will supply the water he needs in abundance, even when water is used in the kitchen or elsewhere at the same time. With an inadequate water system, if bath or shower is started, and another outlet opened, water is not so likely to flow at the shower or tub.

The adequate capacity water system is built for 'round the clock heavy duty service and will supply that requisite for life, "water"—the last thing we want before we retire and the first thing we want when we arise in the morning.

B) Fire Protection

Approximately 17% of rural fires start on the roofs of buildings. If a fire is discovered within a few minutes after it starts, a very small amount of water will extinguish it, providing there is a way of putting the water on the fire without loss of time. Fifty gallons of water available when the fire starts are worth 10,000 gallons 60 minutes late.

The automatic electric water system with a capacity of not less than 5 gpm at 30 pounds pressure, and ¾" garden hose with ordinary nozzle, will reach the roof of the ordinary farm building. This is a minimum of fire protection and is not recommended or recognized by the Underwriters.

The recommendation of the Underwriters is: "An effective fire stream through a small nozzle (3/16 to 1/4") requires 8 to 10 gpm and this should be available for at least two hours." It is not assumed that such a supply will extinguish a fire well underway in a barn or other large buildings. In such cases protection of adjoining buildings is the principal function, and this protection must be available until the fire is well burned out. This amount will allow as effective fire fighting as can be expected without fire fighting equipment.

In every case where the water system is available for fire protection, hoses with nozzles should be conveniently located, not locked in a tool shed or house. They should be hanging out in the open where they can be attached to the nearest hydrants without delay. Should a fire be discovered when the family is away, the passer-by or neighbors could extinguish the fire before it made uncontrollable headway.

When the well is a safe distance from the buildings and the water system is installed in a pit, or above ground installation, the central pole power supply is preferable. This means that the power line runs directly from the pole to the pump. The advantage is obvious — when the water system is installed in the basement of the home or when the power line runs from the house to the pump at the well, in case of fire, there frequently is current failure, either due to burned wires or current being cut off. When this happens, water from the pump for fire fighting is not available. With the central pole installation this does not happen and water is available under pressure under any circumstances.

So, again, fire protection alone justifies an adequate capacity, heavy duty water system.

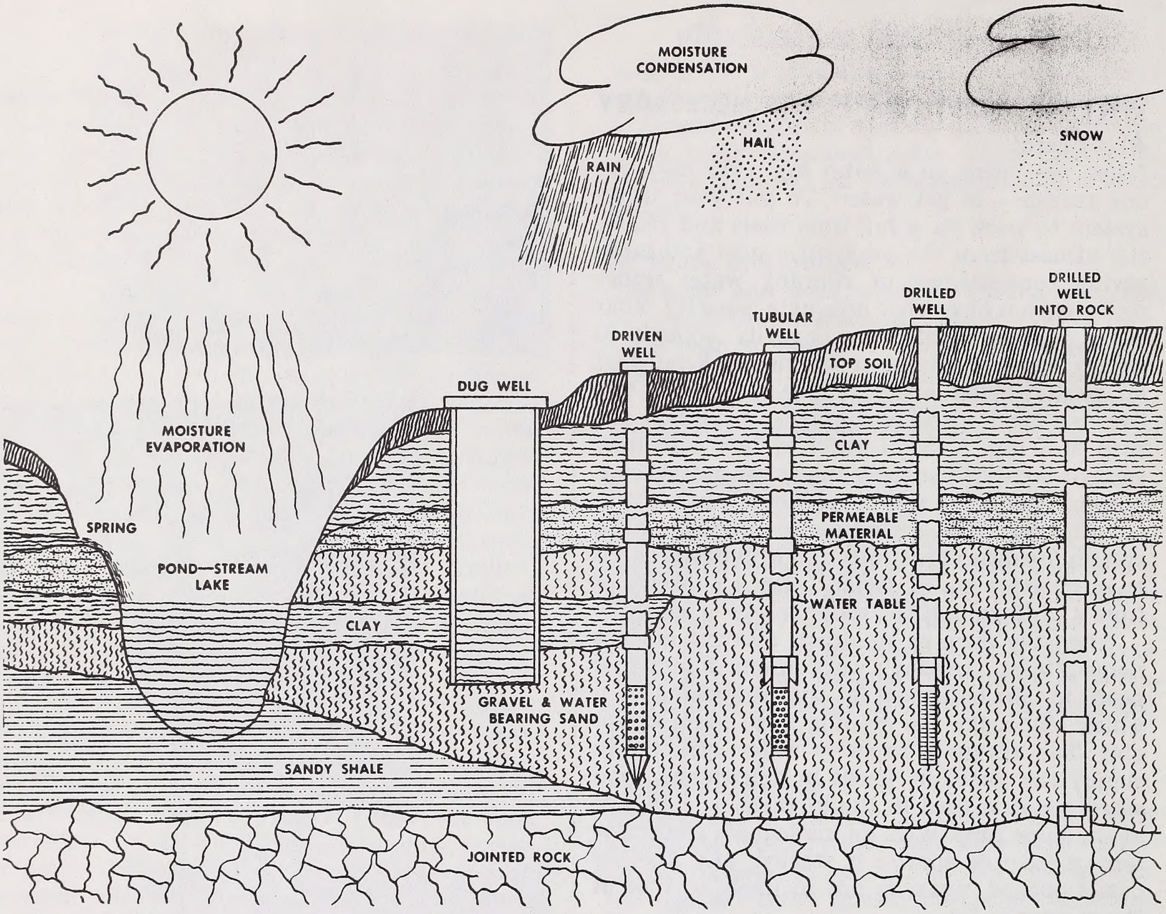


Fig. 1 — Water Sources

SOURCES OF WATER SUPPLY

A) Ponds, Lakes and Streams

A properly developed source of pure water will assure better health, production, sanitation, and more enjoyable living. It is advisable to study the specific needs to be supplied by the source, such as general household uses, drinking, washing, bathing, fire protection, crop production, and animal watering in barn yard or pasture. The chief considerations in the development of the water supply are purity, quantity and economy.

As important as water is to the home owner, the farmer and industry, it should only be used when there is positive assurance that the water source is free from contamination.

Water from ponds, lakes and streams, as well as open reservoirs, is often used for irrigation, stock watering, fire protection, etc; however. waters from these sources usually are not sanitary for human consumption because of possible contamination which may require extensive purification.

Each level of government, county, state and federal, recognizes the importance of pure water to the health of the nation and through county agents, state and national health departments, maintains free testing facilities. Every water source, before it is used, should be tested if it is to be consumed by humans or animals or in the preparation of food for sale. Because health department officials are vitally interested in proving the quality and purity of water supplies, they will gladly cooperate in planning the development of a source and testing it for purity. Their offices have the needed information to enable persons to determine the depth and ground strata through which the well shaft must pass to reach pure water in required quantity and volume. Well drillers rely on this information and use it to good advantage.

If tests reveal that water is contaminated, the health department or local well driller will recommend methods of purifying it. There are available, small chlorinators which may be installed

at the pump and which do the same work as large chlorine purifiers in city water works. Filtration of impure water through gravel, sand or other materials will not remove bacteria, although it may remove much of the sediment and improve the clarity of the water.

The purity of untested water should never be taken for granted. Before it is used, it should be tested or boiled for 10 minutes or more. Typhoid fever, amoebic dysentery and many other serious and fatal diseases may originate with a contaminated water source.

The water sources in Fig. 1 all receive their supply from rain or snow. As water falls, it may collect to form lakes, rivers or ponds which are known as surface waters. The remainder of the rainfall which seeps below the surface of the earth may be absorbed by the plant roots or continue until it meets solid strata and accumulates where it is available as natural spring or well water. Each well shown in Figure 1 shows a different method of obtaining water from underground sources. The following are the various sources of water supply.

B) Cisterns and Reservoirs

Cisterns and reservoirs used for storage of rain water offer a limited source of soft water which should not be used for human or animal consumption unless it is thoroughly boiled or properly treated with chlorine.

C) Springs

Water from springs and pools for domestic use must be carefully checked for purity periodically as the chances of contamination are very great and are not dependable during periods of drought.

Springs not located sufficiently near the home sites or the point of use require extensive piping systems and construction of a basin to collect the water against future needs. The collection box or basin should be large enough to impound most of the flow and should have slots or openings to admit the water flowing from the spring.

D) Dug Wells

The dug well permits the flow of water into the excavation furnishing a relatively large quantity of water from a shallow source. The walls of a dug well should be curved or lined with rocks, bricks, wood or concrete to prevent the entry of surface water and caving. Because of their necessary location in low points of the terrain, close to ground level, dug wells are generally subject to contamination from surface seepage and subsurface drainage.

A high percentage of dug wells now in use are polluted. Every possible precaution should be taken by those using this type of well to guard against pollution. Driven or drilled wells are usually considered preferable because they give greater assurance of greater safety against pollution.

E) Drilled Wells

Drilled wells are installed when greater volume, diameter and depth are needed. In the construction of a tubular well, the drilling operation stops at the water bearing and sand stratum; in the drilled well the casing or pipe is driven down as the well is drilled and extends either to water bearing sand or continues to rock.

There are other types of driven wells such as the open end variety which are less easily clogged with fine particles of sand in areas adjacent to large lakes, but such wells require special apparatus and equipment for proper development and should be done by experienced well drillers who are competent to undertake such work and have the knowledge of the ground strata.

When the well goes down to rock, the casing or pipe is driven down until rock is reached; then drilling continues into the rock to the water supply. This type of well often does not require a screen. As a guide to the better understanding of a drilled well installation, it may be profitable to study typical illustrations of the tubular and drilled wells shown in Figure 1.

A soundly constructed drilled well offers the maximum of efficiency, volume and purity.

PUMPING FUNDAMENTALS

A) Suction

The function of most pumps is to create a vacuum. When the pump is completely installed, the suction line (the pipe from the pump into the well) is filled with air at atmospheric pressure (the weight of the air around us usually measured in pounds per square inch) from the level of the water in the well to the pump. When the pump is started it sucks the air out of the pipe line, thus creating a vacuum. The atmospheric pressure on the water in the well drives the water into the suction line, then to the pump. This is called suction.

At sea level, the weight or pressure of atmosphere is 14.7 pounds per square inch. This means that a square inch column of air from the earth's surface at sea level up to infinity has a weight of 14.7 pounds. As stated, a suction pump develops a suction or reduced atmospheric pressure (vacuum) in its suction chamber. When a pipe is

connected to this chamber has its other end submerged in water exposed to atmospheric pressure and the pump is running, an unbalanced pressure condition exists. Pressure on the exposed water surface is 14.7 pounds per square inch at sea level. Pressure in the suction chamber can be reduced to approximately a minus 14.7 pounds per square inch; thus the greater pressure on the water surface will force water up the pipe to the suction chamber.

As an example, visualize a boy trying to suck pop from a bottle with his mouth entirely over the bottle mouth. Can he lift the pop by suction? No, because the surface of the liquid is not exposed to atmospheric pressure. But when a paper straw is inserted in the pop, suction developed causes the greater pressure on the surface of the pop to force it up the straw.

The next question is, how high can water be raised or lifted by suction (suction lift)? The answer is: A height equivalent to the pressure differential established between the 14.7 pounds of atmospheric pressure on the surface of the water to be pumped, and the suction chamber of the pump.

This raises the problem of converting pounds pressure to feet. It has been proven that one pound pressure from any source will raise a column of water 2.3 feet. If we can remove all the pressure of atmosphere from the pump suction chamber, the pressure difference becomes 14.7 pounds; therefore a perfect vacuum would cause water to rise 14.7 times 2.3, or 33.8 feet. However, due to hydraulic and mechanical losses in a suction pump, 25 feet is considered the maximum practical total suction lift at sea level. At altitudes higher than sea level, total suction life will be reduced 1 foot for each 1000 feet of elevation. As a practical matter, it is advisable to deduct 1.2 feet from the manufacturer's specifications for every 1000 feet above sea level.

B) Friction Loss

The movement of water through a pipe develops friction similar to that of a brake. The amount of pipe friction depends upon the diameter of the pipe, its length and the rate of flow of water in gallons per minute. (The age of steel pipe also has a bearing on the amount of friction loss, because the inside diameter becomes smaller with rust and scale.) The degree to which the flow of the water is retarded by the pipe is known as friction loss.

The use of a pipe that is too small will result in an unsatisfactory flow of water, pressure loss and higher pumping costs. The friction table, Figure 2, shows the loss in feet due to friction in hundred foot lengths of pipe. The friction loss in this table is based on 17 year old pipe. It is very easy to determine the friction loss through any of the pipe sizes shown for any flow of water. The figures on the left show gallons per minute and the figures on the table show the friction loss for each 100 feet of pipe of the various sizes.

For example, 5 gpm through 100 feet of 1″ pipe results in a friction loss of 3.3 feet. The same 5 gpm through 100 feet of ¾″ pipe will result in 10.5 feet of friction loss and 41.0 feet of friction loss through 100 feet of ½″ pipe. If the pipe lengths were doubled then the friction losses would also be doubled.

Friction loss **must** be taken into consideration when pipe is selected for a water system!

The friction loss shown in Figure 2 for 17 year old pipe should be the determining factor for selecting new pipe. All water is corrosive and by following this suggestion, allowance will be made for corrosion and this will result in an adequate flow of water after several years of service.

In order to arrive at friction loss for new pipe, multiply readings by .6.

The friction loss through copper tubing, plastic pipe and new galvanized pipe is practically the same. Friction loss for 10 gpm through 100 feet of 1″, 17 year old pipe is 11.7 feet. Multiply this by .6 and the friction loss through 100 feet of 1″ copper tubing and plastic pipe is 7.02 feet.

Friction loss is also created by the use of plumbing fixtures such as tees, elbows and valves. These also retard the flow of water.

C) Conversion Factors

As we shall see, in the selection of a water system we must convert pounds of pressure to feet, and vice versa. To do this, we must use what is known as conversion factors. They are as follows:

1) **To reduce pounds pressure to feet of head, multiply by 2.3.**

2) **To reduce head in feet to pounds pressure, multiply by .434.**

These factors are arrived at by the simplified method shown in Figure 3.

Use of these factors is necessary to determine the required pneumatic tank pressures to overcome pipe friction loss or elevation. When the necessary pressure is known, the water system can be selected.

The following is a typical example of the application of conversion factors in selecting a water system:

Engineering & Home Design Branch
Family Farm Development Division
Alberta Department of Agriculture
Edmonton, Alberta

LOSS OF HEAD IN FEET, DUE TO FRICTION, PER 100 FEET OF 17 YEAR OLD STEEL PIPE

For New Pipe Multiply Readings by 0.6 — For 25 Year Old Pipe Multiply Readings by 1.2

U. S. G.P.M.	PIPE SIZE												
	½	¾	1	1¼	1½	2	2½	3	4	5	6	8	10
1	2.1												
2	7.4	1.9											
3	15.8	4.1	1.3										
4	27.0	7.0	2.1										
5	41.0	10.5	3.3										
6	57.0	14.7	4.6	1.2									
7	76.0	19.5	6.0	1.6									
8	98.0	25.0	7.8	2.0									
9		31.2	9.6	2.5	1.2								
10		38.0	11.7	3.1	1.4								
11		45.0	13.3	3.5	1.7								
12		53.0	16.4	4.3	2.0								
13		62.0	18.7	4.9	2.3								
14		71.0	22.0	5.7	2.7								
15		80.0	24.2	6.4	3.0	1.1							
16		91.0	28.0	7.3	3.4	1.2							
17			30.5	8.0	3.8	1.3							
18			35.0	9.1	4.2	1.5							
19			38.2	10.0	4.6	1.7							
20			42.0	11.1	5.2	1.8							
21			45.5	11.9	5.5	2.0							
22			50.0	12.9	6.2	2.1							
23			54.0	14.0	6.6	2.3							
24			59.0	15.2	7.3	2.5							
25			64.0	16.6	7.8	2.7							
26			68.0	17.8	8.4	2.9							
27			73.0	19.0	9.0	3.1							
28			78.0	20.2	9.7	3.3	1.1						
29			83.0	21.7	10.0	3.5	1.2						
30			89.0	23.5	11.0	3.8	1.3						
35				31.2	14.7	5.1	1.7						
40				40.0	18.8	6.6	2.2						
50				60.0	28.4	9.9	3.3	1.4					
60				85.0	39.6	13.9	4.7	1.9					
70					53.0	18.4	6.2	2.6					
80					68.0	23.7	7.9	3.3					
90					84.0	29.4	9.8	4.1	1.0				
100						35.8	12.0	5.0	1.2				
120						50.0	16.8	7.0	1.7				
140						67.0	22.3	9.2	2.3				
160						86.0	29.0	11.8	2.9				
180							35.7	14.8	3.6	1.2			
200							43.1	17.8	4.4	1.5			
220							52.0	21.3	5.2	1.8			
240							61.0	25.1	6.2	2.1			
260							70.0	29.1	7.2	2.4			
280							81.0	33.4	8.2	2.8	1.1		
300							92.0	38.0	9.3	3.1	1.3		
325								43.5	10.7	3.6	1.5		
350								50.0	12.2	4.2	1.7		
375								56.0	14.8	4.6	1.9		
400								65.0	16.0	5.4	2.1		
425								72.0	17.2	5.8	2.4		
450								79.0	19.8	6.7	2.6		
475								87.0	21.6	7.3	2.9		
500								98.0	24.0	8.1	3.2		
550									28.7	9.6	3.8		
600									33.7	11.3	4.5	1.2	
650									39.0	13.2	5.3	1.3	
700									44.9	15.1	6.1	1.5	
750									51.0	17.2	6.8	1.7	
800									57.0	19.4	7.7	2.0	
850									64.0	21.7	8.7	2.2	
900									71.0	24.0	9.8	2.4	
1000									88.0	29.2	11.9	3.0	1.0
1100										33.5	13.7	3.6	1.2
1200										39.3	16.1	4.2	1.4
1300										45.6	18.6	4.9	1.6
1400										52.3	21.4	5.6	1.9
1500										59.4	24.3	6.4	2.1

Based on Williams & Hazen Formula with Constant C = 100

Fig. 2 — Friction Table

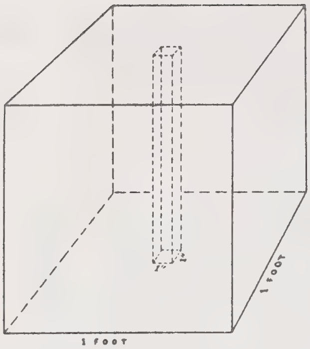


Fig. 3

The above container, 12 x 12 x 12 inches holds one cubic foot of water. A cubic foot of water weighs 62.5 pounds. There are 144 square inches in the base of the above container. Since a cubic foot of water weighs 62.5 pounds, divide 62.5 by 144 and there is a pressure of .434 pounds per square inch for a column of water one foot high.

Height, not volume, determines the pressure per square inch. Since we know a column of water one foot high exerts a pressure of .434 pounds per square inch, we divide 1 pound by .434 and we find that one pound pressure will elevate water 2.3 feet.

A water system, including the tank, is installed at the well in a frost-proof, well ventilated, pit. The pump has a capacity of 9 gpm. The dairy barn is located 250 feet from the well, and with an elevation of 25 feet above the water system location. After referring to Figure 2 the 1¼″ pipe has been selected, with friction loss of 2.5 feet per 100 (250 feet times 2.5 equals 6.25 feet of friction loss). 6.25 feet friction loss plus 25 feet of elevation equals 31.25 feet of friction loss and elevation. It now becomes necessary to find the required pressure to overcome 31.25 extra head. We do this by multiplying 31.25 feet by .434, the factor used in converting feet to pounds pressure. This gives us 13.56 pounds pressure which means that this much pressure will be required to move the water to the dairy barn and nothing more. When it arrives there it will have no further pressure.

In most cases when water leaves the pressure tank, it is desired to be at minimum pressure of 20 pounds and a maximum pressure of 40 pounds. In our example, therefore, we would have to add the 13.56 pounds pressure to the 20 and also the 40 pounds to determine corrected setting of the pressure switch, for this installation. (The pressure switch starts the pump motor when the pressure in the tank has declined to the minimum and stops it when it has reached the maximum.) Therefore, our pressure switch setting for this example would be, to use round figures, 34 pounds minimum and 54 pounds maximum.

Now, let's assume that in our example, instead of using 1¼″ pipe, we used 1″ pipe. Referring to our friction table we note that 1″ pipe at 9 gpm would create 9.6 feet friction per 100 feet of pipe. Multiplying this by 2.5 the friction loss in 250 feet of 1″ pipe in our example would be 24 feet.

With ¾″ pipe, the friction loss would increase to 78 feet, more than three times the elevation!

Obviously, the proper pipe size for the above installation is 1¼″. This example shows very clearly that when there is excessive pipe friction loss as would be the case with ¾″ pipe, the pumping cost would be much more. Always use pipe size large enough to keep pipe friction losses to a minimum. Figures 4 and 5 on page 13 explain this further.

The preceding examples assume the use of steel pipe. Plastic and copper pipe do not create as much friction loss as does steel, as was previously indicated.

D) Total Head

The total head is the load on the pump designated in feet.

When reciprocating or plunger type pumps are to be used, it is necessary to know the total head in order to determine the size electric motor to place on the pump. The loading of motors on submersible and ejector type pumps will be discussed later.

The total head is a sum of the vertical lift from the water to the pump, plus friction loss, plus the distance the water is to be elevated after leaving the pump, plus the friction loss in the discharge lines (pipes leading from the pump to the storage tank or point of discharge), plus any desired pressure at the point of discharge.

Here again the pipe friction loss must be taken into consideration. The more friction loss in both suction and discharge lines, the greater the total head of our pump load. Figures 4 and 5 demonstrate how total head is computed. In Figure 4 we see that the total head is 148.3 feet. The total suction lift is 22.3 feet and the total discharge head is 126 feet. In this installation the application of pumping fundamentals stands out. Thirty feet elevation plus the friction loss of 4 feet through 100 feet of 1½″ pipe, multiplied by .434 shows that 14.75 pounds pressure is required to overcome the elevation and pipe friction loss between the water system and the house. When the pressure switch is set at 35-55 pounds, we will have a minimum pressure of 20 pounds and a maximum pressure of 40 pounds available at the service line in the basement.

SHALLOW WELL
TOTAL HEAD — HORSE POWER

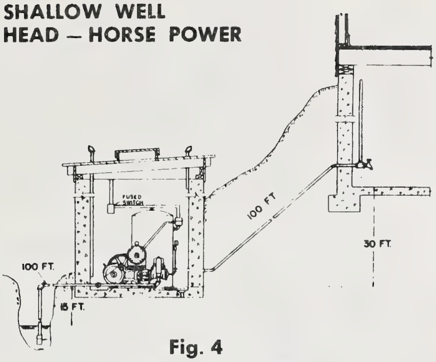


Fig. 4
CAPACITY 17 GPH

15.	Ft. Vertical Lift
4.3	Friction Loss 17 GPM through 115 feet 1½ inch Suction Pipe.
3.	Ft. Friction Loss Valve and not more than 2 Elbows.
22.3	Ft. Total Suction Lift.
30.	Ft. Elevation from Pump and Tank Location to Basement.
4.	Ft. Friction 17 GPM through 100 Ft. 1½ inch Pipe and 2 45 degree Elbows.
92.	Ft. 40 pounds Maximum Pressure at Basement x 2.3.
148.3	Ft. Total Head in Feet.
30′	Elevation plus 4′ Friction Loss 34 x .434 equals 14.75, Pressure required to overcome Discharge Friction and Elevation.
14.75	Lbs. required to overcome Elevation added to switch setting of 20-40 lbs. equals New Switch Setting of 35-55 Lbs.
148.3	Total Head in Feet x 17 GPM equals 2521.1.
2521.1	Divided by 2000 equals 1.26 Horse Power.

1½ HP Motor required on above Pump.

DEEP WELL
TOTAL HEAD — HORSE POWER

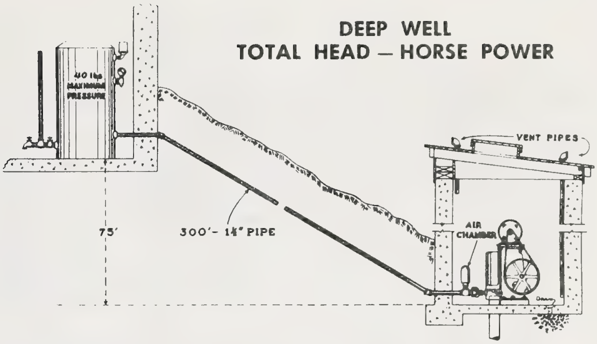


Fig. 5

6″ Well, 150′ Deep, 120′ to Low Water Yield 12 GPM.
We have selected V2958-AMT, with 2¼ Figure 3102 Double Acting Working Barrel. Capacity 10.5 GPM.
What is Total Head in Feet?
What Pressure will be required to overcome 75′ Elevation and Pipe Friction Loss in Discharge?
What HP Motor with Double Acting Working Barrel?
What HP Motor with Single Acting Working Barrel?

120′	To Low Water.
75′	Elevation from Pump to Tank in Basement.
5′	Friction Loss 300′ Discharge Pipe and Elbows.
92′	40 lb. Tank Pressure x 2.3.
292′	Total Head in Feet.
75′	Elevation plus 5′ Friction Loss — 80 x .434 equals 34.72 Pounds Pressure required to overcome Elevation and Friction.
292′	Total Head x 10.5 GPM equals 3066.
3066	Divided by 2000 equals 1.53.
1.53	Plus 15% equals 1.53 x 115 equals 1.759 — 2 HP Motor required for Double Acting Working Barrel.
1.53	Plus 50% — 1.53 x 150 equals 2.29 HP — 3 HP should be used for Single Acting Working Barrel.

E) Horsepower

Reciprocating or plunger pumps are available in different horsepower ratings. The more horsepower, the more work the pump will do in terms of feet of head and gallons per minute. So, in selecting our water system, we must determine the horsepower needed to operate the pump.

A simple rule for arriving at required horsepower is: Pump capacity in gallons per minute, multiplied by the total head in feet, divided by 2,000 equals horsepower. This rule applies to shallow well reciprocating pumps.

Figure 5 illustrates the deep well installation where the deep well reciprocating pump is located in a frost-proof pump house. The pump capacity of 10.5 gpm is discharged through 300 feet of 1½″ pipe into the pressure tank in the basement of the house, which is 75 feet higher than the well. Total head in feet for this installation is 292 feet.

The horsepower requirement for this installation is determined by multiplying the pump capacity in gallons per minute by the total head in feet and dividing by 2,000, plus the correct compensating factor.

F) Shallow and Deep Wells

In general a well of 25 feet or less in depth is known as a shallow well. One over 25 feet is called a deep well.

Actually, it is the distance down to the pumping level in the well that dictates whether a shallow or a deep well type of pump must be installed. For instance, if a well were say 200 feet deep and the water, in sufficient quantity, were available at only 20 feet below ground level, a shallow well type pump could be used.

Remember the limitations of shallow well pumps as discussed under "Pumping Fundamentals." Lifts in excess of 25 feet will require the use of deep well equipment.

TYPES OF PUMPS

A. Centrifugal Ejecto, Single Stage

1) **The Ejecto pump** combines two principles of pumping, that of the centrifugal pump and that of the ejector assembly. The centrifugal pump has been manufactured in one form or another for many years. Using steam as the drive fluid, ejectors were used years ago to put water into boilers of the old steam threshing engines. Both are pumps, and when combined the Ejecto pump was the result.

a) Shallow well units — are limited to a maximum pumping depth of approximately 25 feet, which is the practical depth limit for lifting water into an evacuated space by the use of atmospheric pressure. These shallow well units have the ejectors placed inside or next to the casing of the centrifugal pump.

b) Deep well units — are used when the pumping level of the well is more than 25 feet below the pump location, beyond the limits of the shallow well units. In this system the ejector is submersed in the well water and connected to the pump with two pipes, known as the pressure pipe and the delivery pipe.

The pressure pipe carries pressure water from the discharge section of the centrifugal pump down to the nozzle in the ejector assembly. The delivery pipe is threaded to the top of the venturi assembly on the ejector and carries the re-circulating water plus the well water up to the pump. This operation is smooth and continuous.

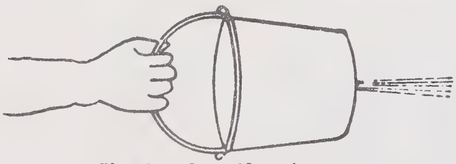


Fig. 6 — Centrifugal Force

2) Principle Of Operation

An easy way to describe the operation of a centrifugal pump is to compare it with swinging a pail partially filled with water in a circle. The water stays in the bottom of the pail. Centrifugal force keeps it there.

Had a hole been punched through the bottom of the bucket, as in Figure 6, a stream of water would have been released. The distance the stream would have carried would have depended entirely upon the speed at which the bucket had been revolved. The faster the bucket was swung around in the circle the greater the velocity at which the water would leave the hole in the pail. This is true of the centrifugal pump.

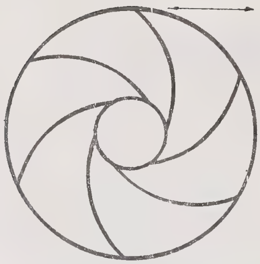
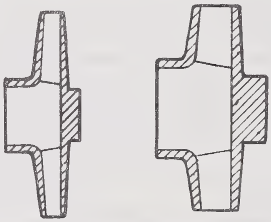


Fig. 7 — Impeller Cross-Sectioned

However, instead of using a pail, the water enters the hub or eye of the impeller and is thrown out at the rim of the impeller. This means that the diameter of the impeller and its revolutions per minute determine the velocity of the water as it leaves the rim of the impeller. The greater the velocity the higher the pressure the pump will develop. The release of the water at the impeller rim creates a vacuum at the impeller hub.

Figure 7 shows a cross-section of an impeller, hub in the center and the several vanes running out through which the water is discharged.



Impellers Same Diameter

Figures 8 and 9 again show cross-sections with the impellers cut in half. Both are the same diameter. Figure 9 will pump much more water because of a larger hub or intake and larger cross-section for the water to pass through the impeller. However, the impellers in Figures 8 and 9 are the same diameter, and when operated at the same speed will develop approximately the same pressure.

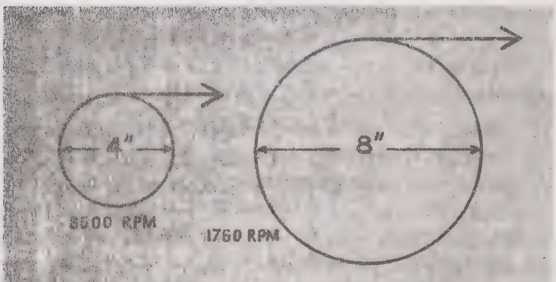
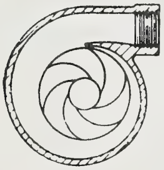
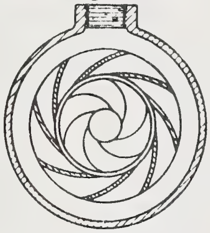


Fig. 10 — Same Rim Speed

Figure 10 shows a four inch impeller operated with a 3500 rpm motor and an eight inch impeller operated by a 1750 rpm motor. Even though the four inch impeller is only half the diameter of the larger, it is operated at twice as fast causing both impellers to have the same rim speed, which results in the same pressure.



Volute Type
Fig. 11



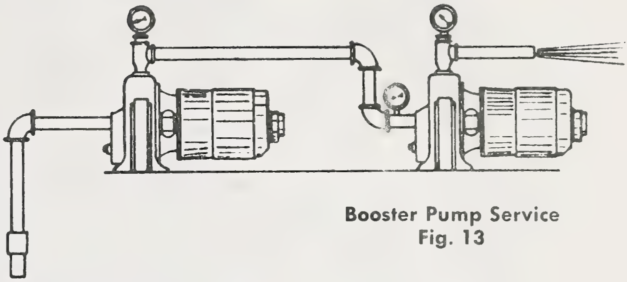
Turbine Type
Fig. 12

Generally speaking, there are two types of centrifugal pumps. Figure 11 shows the volute type in which water leaves the impeller rim at high velocity into the volute case. The volute case increases in cross-section until it has reached its maximum at the pump outlet. The purpose of this case construction is to slow up the high velocity and low water pressure while converting to low velocity and a useful high water pressure.

The turbine type pump in Figure 12 changes the high velocity of the water as it leaves the rim of the impeller to low velocity and high pressure by discharging water into numerous vanes in the diffuser plate. These vanes have a narrow cross-section where the water enters from the impeller and is much wider at the rim of the diffuser plate. This causes the high velocity water to be changed into useful pressure.

An interesting analogy would be the dropping of a baseball from a height of 200 feet. The velocity of the ball would be 113½ feet per second as it hit the ground. To throw the ball back to the height of 200 feet would require that the ball leave the thrower's hand at the same 113½ feet per second. The force with which the ball is thrown determines the height or distance the ball will travel. The velocity of the water as it leaves the rim of the impeller determines the pressure the pump will develop.

Because of the smooth, non-pulsating flow from a centrifugal pump it is ideally suited for booster pump service. An example of booster pump service is shown in Figure 13. Since the first pump has a capacity of 16 gpm at 20 pounds pressure, this water will enter the inlet to the second pump at 20 pounds pressure. The second pump will use the incoming pressure and add it to its own pressure. The water then leaves the



Booster Pump Service
Fig. 13

second pump at 40 pounds pressure. If a third pump were added the final discharge pressure would be 60 pounds. There would be no change in the amount of water discharged which would remain at 16 gallons per minute.

Figure 14 shows the Ejecto pump consisting of an ejector assembly and a centrifugal pump. When the discharge pressure of the combination is 40 pounds, the ejector assembly will be putting water into the hub of the impeller at 10 pounds pressure and the centrifugal will be developing 30 pounds, giving a discharge pressure of 40 pounds.

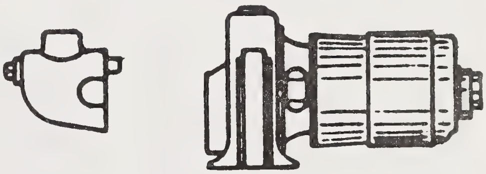


Fig. 14

High velocity of the water has been mentioned in describing the operation of the centrifugal pump. Where there is high velocity there is low pressure. Figure 15 shows a fire hose nozzle. When this nozzle is in action and the high velocity stream leaves the nozzle tip, most people think of high pressure. Actually, there is a low pressure and high velocity in the nozzle stream. If it were possible to have a pressure gauge on the hose where the nozzle is attached and this gauge registered 100 pounds when the water entered the tapered nozzle, the velocity would increase and the pressure would dissipate. If it were possible to have a pressure gauge at the nozzle tip, the pressure would be practically at zero.

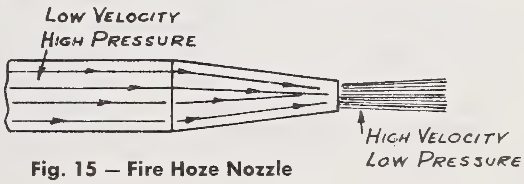


Fig. 15 — Fire Hoze Nozzle

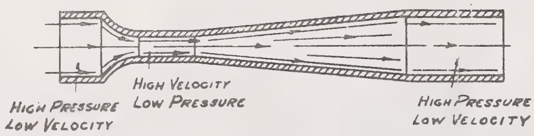


Fig. 16 — Venturi Tube

Figure 16 shows a venturi tube as used with all Ejecto pumps. The water enters the nozzle which is just below the throat of the venturi tube. This entering water is at high pressure and it leaves the nozzle at high velocity and low pressure. Because of the high velocity of the water as it leaves the nozzle tip, there is a low pressure or partial vacuum created. Atmospheric pressure then drives water through the foot valve and into the venturi tube with the nozzle stream. Since the venturi tube now flares out, just the reverse of the fire nozzle, there is a change back to low velocity and useful pressure. This carries the recirculating water and the well water up to within suction distance of the centrifugal pump, when the pump is operating at its minimum operating pressure. Maximum pump flow is now possible.

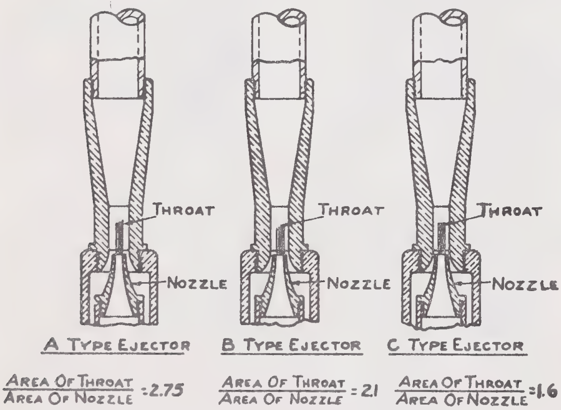


Fig. 17 **Fig. 18** **Fig. 19**
Ejector Ranges

Figures 17, 18 and 19 show three ejector assemblies that are typical of all makes of jet pumps. Figure 17 is designed for a maximum setting of 60 feet and when operating at its operating pressure it will discharge one gallon of water for every 1.3 gallons circulated. Figure 18 is designed for settings of from 60 to 90 feet and requires approximately 1.7 gallons of circulated water for each gallon delivered. Figure 19 is designed for lifts of from 90 to 120 feet and requires approximately 2.5 gallons of circulated water for each gallon delivered.

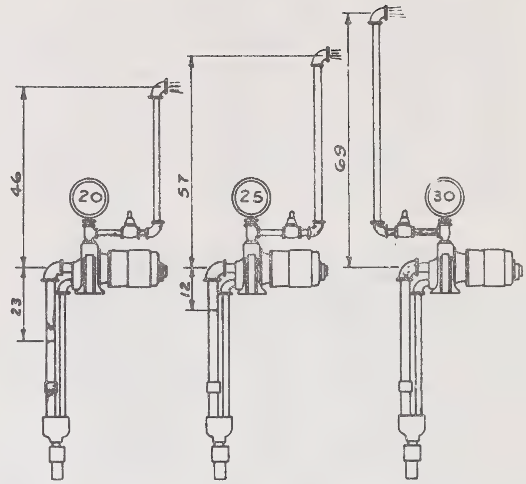


Fig. 20 **Fig. 21** **Fig. 22**
Total Operating Conditions

Figures 20, 21 and 22 show the discharge and suction lifts when the pumps are operating at 20, 25 and 30 pounds pressure. The total head is the sum of the suction lift and discharge head when operating at the lower pressures.

In Figure 20 the pump is operating at 20 pounds pressure which equals 46 feet of head, (20 lbs. × 2.3) and a suction lift of 23 feet. The circulating water leaves the pump at 20 pounds pressure and since the ejector is installed at 46 feet there is 20 pounds gravity pressure, (46 ft. × .434). This causes the circulating water to enter the ejector nozzle at 40 pounds pressure. The high velocity nozzle stream jumps from the nozzle tip to the venturi throat which creates a vacuum in that area allowing atmospheric pressure to drive water through the foot valve into the ejector body. As this water passes through the throat of the venturi, along with the circulating water, it is slowed down to useful pressure and is carried up to within suction distance of the pump.

Figure 21 shows 25 pounds discharge pressure, and when added to the gravity pressure of 20 pounds, circulates water through the jet nozzle at 45 pounds pressure. Again, the venturi tube changes this high velocity back to useful pressure which now carries the water up to within 12 feet of the impeller. The total head is now the same as before. However, the discharge head is 57 feet (25 lbs. × 2.3) and the suction lift is 12 feet.

When the discharge pressure is 30 pounds, as shown in Figure 22, the circulating water leaves the pump at 30 pounds, picks up the 20 pounds gravity pressure, and circulates through the

WEAK WELL, DEPTH 92' – JET SET AT 55' – 35' TAIL PIPE

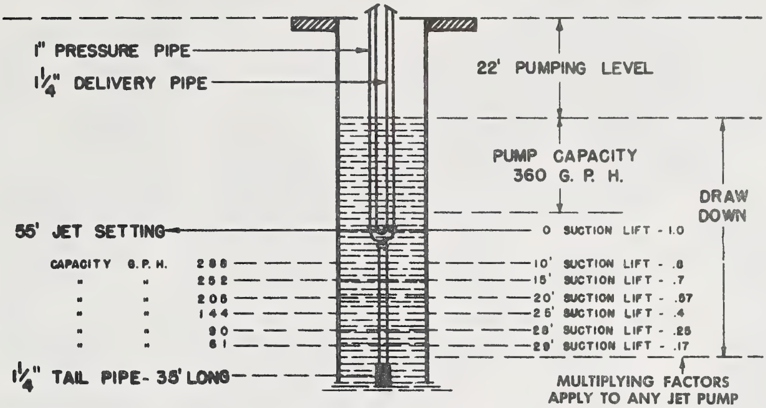


Fig. 23 — Weak Well Tail Pipe Usage

ejector nozzle at 50 pounds pressure. Again, the venturi changes the high velocity stream back to useful pressure, which carries the water to the impeller of the pump at zero pressure, and the discharge head is now 69 feet, (30 lbs. × 2.3).

When the example in Figures 20, 21 and 22 is operating at 40 pounds pressure (which is a common pressure switch setting), the water enters the impeller at 10 pounds pressure. The pump adds its 30 pounds pressure, the pressure it will develop, and the final discharge pressure is 40 pounds.

3) Performance Characteristics

A distinctive feature of the Ejecto pump is the fact that the horsepower requirement remains practically constant regardless of discharge pressure or well lift. A given size of pump and motor will furnish generous amounts of water from well lifts of from 30 to 180 feet. This is accomplished by using different ejector assemblies only.

All ejector pump manufacturers make an assortment of ejector assemblies to fit varying well conditions. Each ejector assembly is designed for a certain maximum lift.

This brings up another characteristic which is the deeper the pumping level the more water has to be circulated. And as the circulating water increases the pump capacity delivered decreases. In this instance, attention should be called to the possibilities of the ejector pump when used on weak producing wells.

The ejector pump meets the conditions of the "weak" well better than any other type of deep well pump, when properly installed. See Figure 23. Assume that these are the known conditions: (a) well capacity has proven inadequate for normal pumping, (b) well is 95 feet deep with water standing at 22 feet below ground level, and (c) well is 4 inches inside diameter or larger.

The solution to this problem is to install a foot valve on the bottom end of 35 feet of 1¼ inch pipe and lower into the well. Next secure the twin type ejector assembly to the tail pipe and then add 55 feet of 1 inch pressure pipe and 1¼ inch delivery pipe above the ejector assembly. The pump can now be brought into service.

When properly installed, this installation provides the maximum water from a weak producing well since the regular pump capacity will be available until the pumping level lowers below the ejector assembly setting. Then as the water lowers in the tail pipe the pump capacity becomes less and less until the water is about 30 feet below the ejector assembly. Loss of priming cannot occur because no pump can exhaust all of the water from a 35 foot tail pipe.

This type of installation makes it unnecessary to raise the pump's operating pressure, which if done, would have two bad effects. The first would be a water-logged pressure tank if an air volume control that depends on vacuum and the second would be limited pump capacity all the time.

As mentioned earlier, the characteristics of the straight centrifugal pump and the ejector pump do vary in several ways. With the straight centrifugal as capacity increases with decreasing pressure, the horsepower requirements increase accordingly. With the ejector pump the capacity is always approximately the same. As the discharge pressure or well lift increases, the percentage of water that is circulated increases, and the water discharged by the pump decreases accordingly.

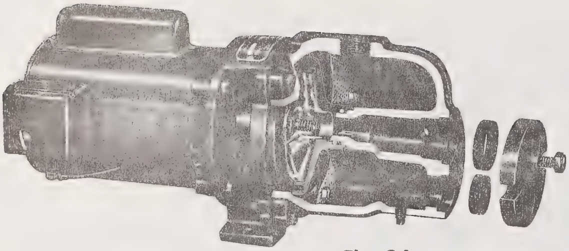
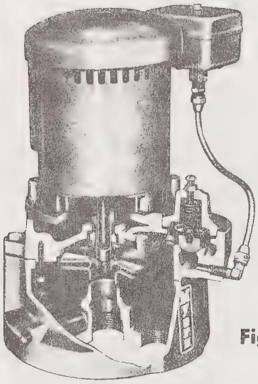


Fig. 24



Horizontal and Vertical Single Impeller Models

Fig. 25

These characteristics must be considered when selecting the correct pump for various types of installations. For an installation where there is considerable elevation between the pump location and the places where the water is to be used, the necessary pressure must be checked and if too high for efficient ejector pump operation, a reciprocating, a dual impeller ejector pump or a submersible should be selected. Pipe friction loss must also be figured since excessive friction loss will result in reduced and unsatisfactory delivered pressures.

Regardless of the make of the ejector pump the pressure switch settings should not be raised higher than shown in the manufacturer's catalog. When the switch setting is raised the capacity will be considerably less and the user will be dissatisfied due to inadequate capacity.

4) Construction Features

To meet the requirements of the trade the ejector type pump is being produced both in the horizontal and vertical construction. They are also supplied with single impeller as well as several impellers, see Figures 24, 25, 28 and 29.

In general, ejector pumps require no oil or grease, are quiet in operation, require no attention, use non-adjustable rotary seals, can be offset from the well, safe, only one moving part, smooth discharge flow, low first cost and low upkeep.

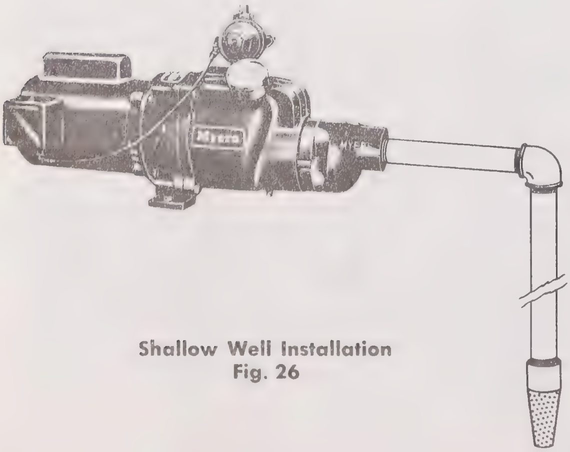
Specifically, a customer is also entitled to the plus features now available in this equipment. These would be:

a) "Fire-Cured" Epoxy protected pump parts.
b) Standard brand motors and components with overload protection built-in.
c) Perfectly aligned stainless steel pump shaft.
d) Mechanical shaft seal.
e) Dynamically balanced impeller.
f) Replaceable bronze wear rings.
g) Fast-connect flange.
h) Automatic Pressure Regulator.
i) Slip joint coupling on pump discharge.
j) Reversible adapter fittings.
k) Bronze or Epoxy protected ejector assembly.
l) Bronze foot valve.
m) Full convertibility if pumping level drops.
n) Certified Performance.

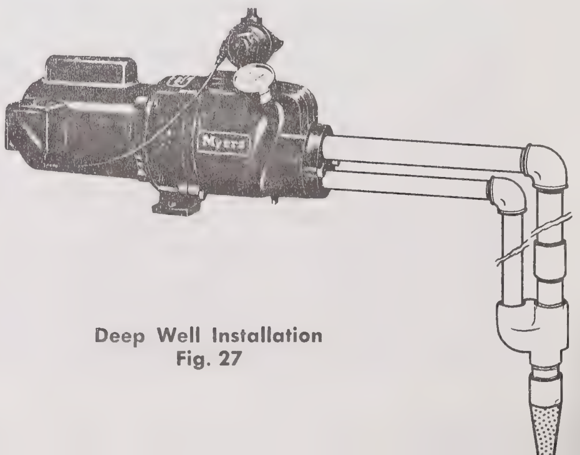
5) Applications

Capacities to 2450 gallons per hour — pressures to 80 pounds — ejector settings to 180 feet — ⅓ through 2 horsepower sizes, Ejecto Pumps are serving their owners efficiently and economically on farms, in suburban areas, in industry and agriculture — wherever water is needed.

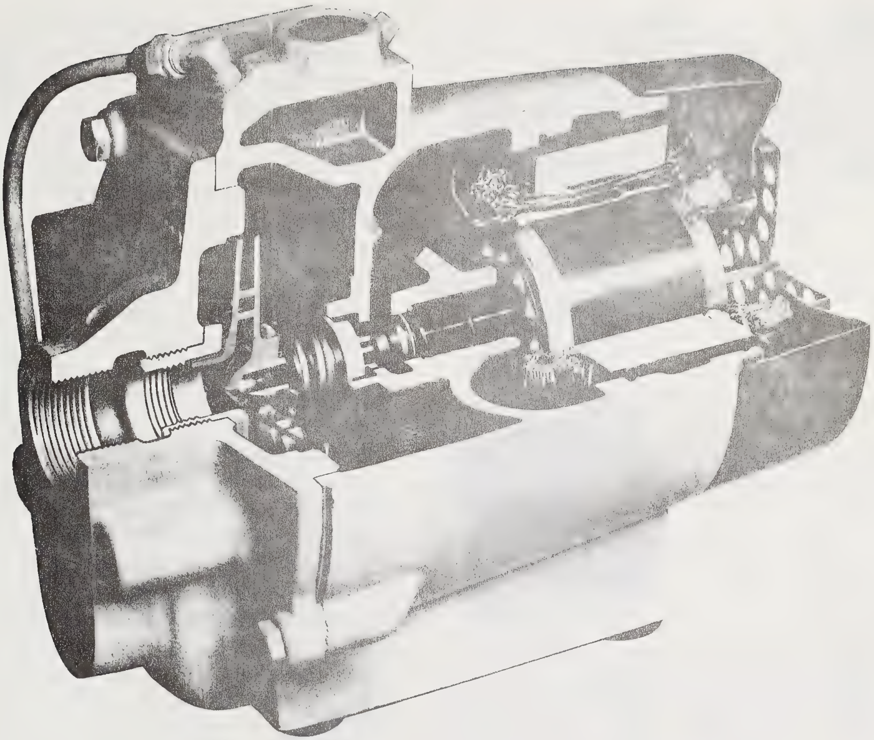
Because of their construction Ejecto Pumps need not be set directly over the water source. They may be off-set at any reasonable distance. See Figures 26 and 27.



Shallow Well Installation
Fig. 26



Deep Well Installation
Fig. 27



A-1) Integral Ejecto

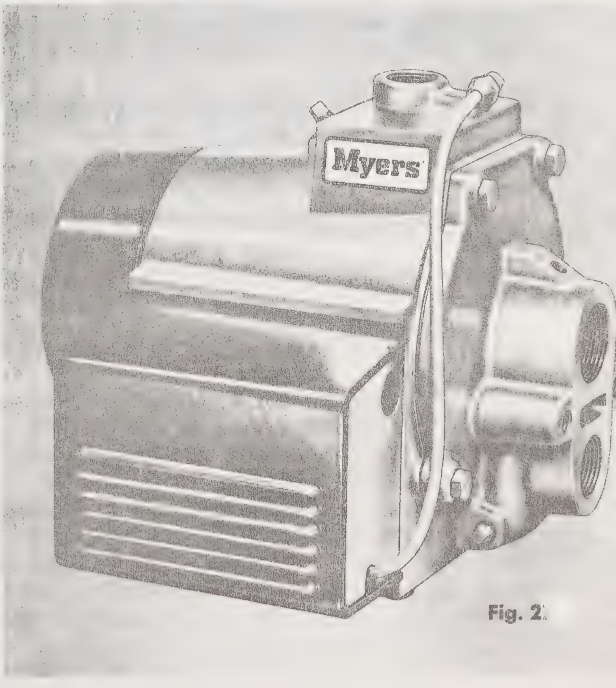
An entirely new concept in jet pump construction is reflected by the Myers "IN" series EJECTOS, shown in Figure 27A.

Here for the first time in the industry is an integral pump and motor assembly in one common enclosure. No longer is there a bracket between the pump and the motor. Since it is more compact it is more powerful with resulting higher efficiencies.

Because the electric motor is enclosed in a heavy cast iron housing it is more efficient in cooling. Because the motor starts thru the use of a current operated relay, rather than a centrifugal device and switch, it is the quietest electric motor on the market. It can almost be heard when operating.

All components are instantly accessible for checking, even the motor. And the "IN" EJECTOS are completely field serviceable. This assures each owner of the shortest possible "down" time if service is needed.

The "IN" series EJECTOS are for convertible shallow and deep well usage or for shallow well service only.



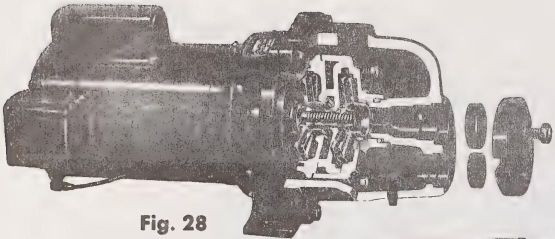


Fig. 28

Horizontal and Vertical Two-Stage Models

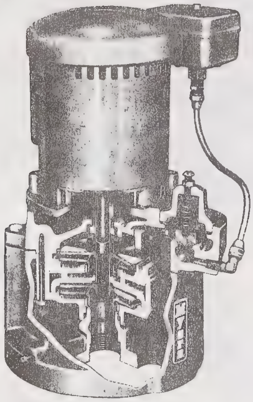


Fig. 29

B) Centrifugal Ejecto, Two Stage

1) The operation and characteristics of the single stage Ejecto pump have been discussed and thoroughly covered in the previous chapter. These same characteristics apply to the two-stage or two impeller pumps. See Figures 28 and 29.

The two impellers develop more pressure than is possible with a single impeller of the same horsepower. This higher pressure makes it ideally suited for deeper wells or for installations where a higher discharge pressure is necessary because of elevations or excessive pipe friction loss.

While single impeller ejector pumps are usually limited to lifts not to exceed 120 feet, because of design considerations, theoretically there seems to be no limit to which a multi-impeller pump could be used. But on the basis of cost and efficiency it soon loses its appeal because the same work or more can be done for less money by other types of deep well pumps.

C) Submersible Pumps

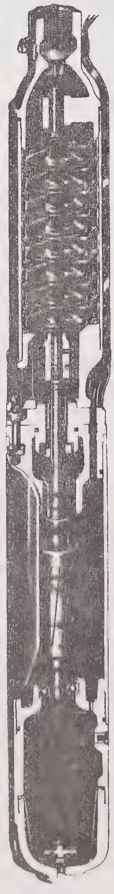
1) While the submersible type pump, as we know it today, was not in general usage prior to 1945, it actually had its conception before the first World War. Early development work was done in foreign countries where the submersible was designed for pumping oil wells and mine dewatering. These were very large capacity pumps and some were available for lifts of several thousands of feet. Also, due to the nature of their use, they had heavy ornate castings and were hand-made units.

With the introduction of American made submersibles, for small diameter wells on a production basis, the quality of the equipment has gone up and prices have come down. Add to this the fact that submersibles are the most efficient method of securing water from deep wells and there should be no astonishment as regards their immediate acceptance by the trade. Submersibles are also used for all kinds of shallow well service.

2) Principle Of Operation

The submersible in the fractional and smaller integral horsepower sizes is designed for use in 4 inch inside diameter and larger wells. This accounts for the cylindrical construction as shown in Figure 30.

In operation the entire pump and motor assembly is completely submerged in the water supply. The motor runs at 3450 rpm, approximately, and drives the pump impellers at the same speed. Water enters at the inlet to the pump and is forced upward through a single drop pipe to the required point of discharge. This point of discharge can be into a pressure tank or any other place the water is needed.



Submersible Pump and Control Box
Fig. 30

Here is truly a simple pump, yet a pump that has required considerable experimental work and development because it is designed to "live" under water, out of sight. By no stretch of the imagination can it be considered a "cure-all" for every pumping problem. There is no such a thing. But the submersible has many practical applications and it is definitely the pump with a future.

3) Performance Characteristics

The performance of the submersible pump is the same as the multi-stage centrifugal in that as the pressure increases the capacity decreases and the horsepower requirement also decreases. In the range of operation from low to high pressure or low to high capacity there can be no overloading of the motor on the pump.

A submersible may be designed with emphasis on pressure (for deeper settings) or on capacity, or a combination of both. But one is only obtained at the expense of the other unless the horsepower is increased. Thus a ½ horsepower pump with 10 impellers (designed primarily for capacity) would deliver greater capacity at 80 feet than a ½ horsepower pump with 12 impellers (designed for pressure). But the latter might raise water from an extra 100 feet of lift. Horsepower alone would not determine the capacity of the submersible, but horsepower plus the number of impellers would indicate the relative capacity and pumping depth.

Like with the centrifugal pump, it can be said that in general the pressure varies with the number of impellers and capacity varies with the design of the impellers.

The electrical characteristics of the submersible motor are similar to a surface motor so the operation is similar on low voltage, that is, the motor speed drops off and the current increases. With a surface motor this increased current means increased heat and causes the overload to trip. The submersible motor has the advantage that the increased heat, due to low voltage, does not affect the winding as this heat is easily dissipated to the well water. Too low voltage will cause the relay to stay in the starting position and, of course, this increases the current and causes the overload to trip. Generally speaking, however, the submersible will operate better on low voltage than the surface type motor.

If the incoming power to the motor is correct the motor will operate at constant temperature, summer or winter, and almost regardless of location in the world. The well water is the cooling agent. And in operation in the well the unit is practically noiseless. This is an ideal feature for operation in home usage.

4) Construction Features

a) Pump End.

As indicated, the quantity of impellers is important for the loading of a submersible motor. The construction of the impellers is also very important.

The submersible operates like any centrifugal multi-stage pump. Each stage added increases the head or pressure by a set amount. For example: a pump that will deliver 10 gallons per minute per stage, each stage added will increase the head pressure by 10 pounds per square inch. There will be no increase in gallons per minute.

A stage consists of an impeller, a diffuser and a wear plate or wear ring. The diffuser consists of stationary vanes that have tapered sections similar to a venturi tube. The high velocity water from the impeller is slowed down in these passages and converted into useful pressure. The diffuser also guides the water into the next impeller inlet.

There are several types of diffusers used on a complete line of submersible pumps and each has certain features that are desirable depending on where they are used.

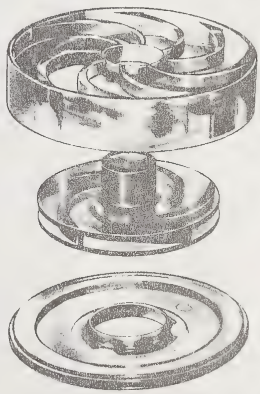


Fig. 31 — Pancake Type Submersible Stage

Figure 31 shows the flat or pancake type of impeller with mating parts to make up a stage for submersibles when good capacities and high heads are desirable. These are the direct diffusion design which use a small impeller in relation to the pump shell and gives high efficiency.

With this construction water discharged from the impeller enters the diffusion ports directly and then into the guide vanes. More impelle are needed to make a given head because the impeller diameters are smaller.

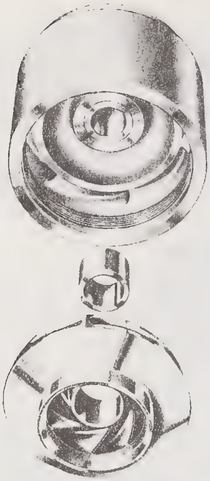


Fig. 31A — Bowl Type Submersible Stage

Figure 31A shows the impeller and diffuser needed when high capacities and medium heads are desirable. This is called a bowl type and is used on all larger submersibles and deep well turbines.

With this construction the water leaves the impeller and is directed into tapered passages that spiral upward in a smooth curve resulting in high efficiency. This construction also permits the use of a relatively large impeller to be used in relation to the outside diameter of the pump.

Pump shafts, made of the best grade of stainless steel, should be threaded to the motor shafts by reverse threads. This makes a rigid connection and eliminates the noise from single phase vibration that is found in some submersibles that use a splined type coupling.

b) Motors.

Because submersible motors must live their entire lives submerged in water, the principal design objective is to make them "wet-proof." The main difference in such motors is the difference in protecting the windings and providing lubrication for the motor bearings.

There are three general methods of doing this and each type is being used in submersible motors today. The potted or canned motor is made by taking the stator winding and completely encasing it in a can or a housing. The inner liner is usually stainless steel of from five to ten thousands of an inch thick. The outer shell is also stainless steel and the end caps are stainless steel. The outer and inner tubes are welded to the end plates. After this is completed the can is then filled with a plastic compound. The rotor then operates in water or oil emulsion.

The second type is similar in construction to the canned motor but the windings are protected by a plastic coating instead of a can. With this type also, the rotor operates in water or oil emulsion.

The third type, Figure 32, is the highly efficient oil filled motor. With this type the windings are open and operate completely surrounded by oil. The rotor, bearings and seal all operate in clean oil.

Because there are three types of construction used in submersible motors it is felt that some discussion of their respective features would be in order.

The canned motor allows the rotor and bearings to operate in water. This construction has the advantage that the motor is not filled with any liquid but the well water. However, one disadvantage is that heat dissipation is poor due to the plastic filler. It will operate satisfactorily at normal current but if the current increases, due to low voltage or a tight pump, and the overload does not function properly, the plastic swells and causes the inner liner to grab the rotor and stop the motor. Operation under this continued condition can cause the liner to fail and allow the windings to become wet and fail. Another disadvantage is that many well waters are corrosive. Repairs of the canned motor are expensive.

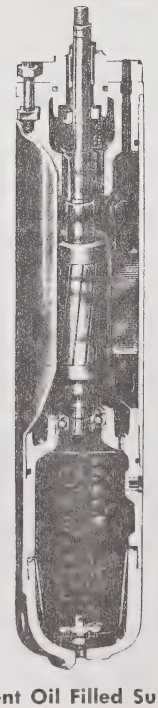


Fig. 32 — Efficient Oil Filled Submersible Motor

A study of this illustration discloses two entirely separate compartments for the motor oil. One body of oil surrounds the motor windings only and cannot mix with the other oil. Neither the quantity nor the quality of the oil in this area will vary over the years of motor use. The oil does not become contaminated with water or foreign substances. Protection of the windings in this way is the secret of long under-ground life of the submersible motor.

The oil in the other compartment emanates from the spring loaded, double diaphragm assembly and keeps the oil around the bearings, rotor and rotary seal. This is not a canned type motor but is a liner type, a new concept in submersible motors. Since the balance system puts the same pressure inside the motor as the outside well pressure the rotary seal, "O" rings and stator winding work under a very low differential pressure. It is desirable that the inside pressure against the rotary seal be several pounds higher than on the outside; hence the spring loading of the diaphragms.

In general, there is sufficient oil in the reservoir for some 15,000 hours of operation or at least 10 years of water system use, based on approximately 4 hours use per day. The pump should be pulled after this period and refilled with oil. However, the liner type motor will operate correctly on the original oil supply or oil and water, or water only. Another Myers first.

The stator in the oil filled motor is wound with conventional wire having the same insulation used in air-cooled motors at ground level. However, the submersible motor must never be run unless it is submerged in water because it will quickly fail due to a lack of cooling.

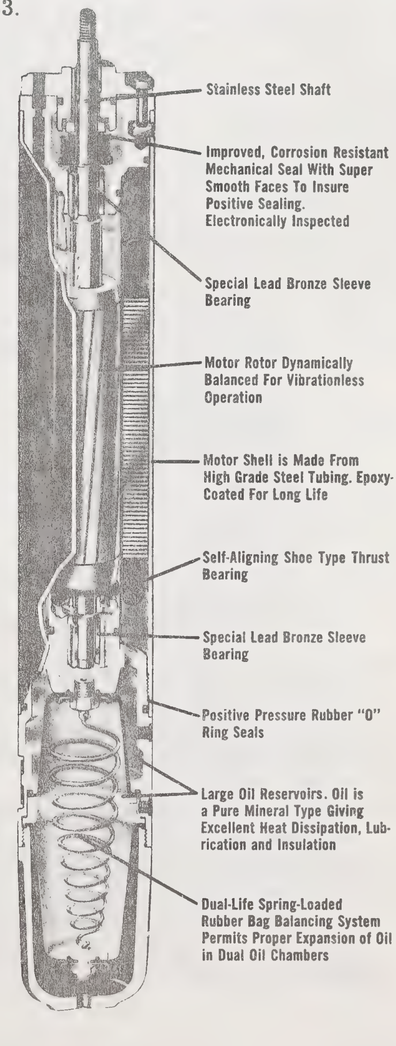


Fig. 33 — Dual-Life Oil Filled Submersible Motor

The construction of the plastic encased motor is similar to the canned motor. This motor uses a rotary seal and expansion bellows so that the motor can be filled with an oil emulsion. This construction is superior to the straight water motor in that the oil gives protection to the inside of the motor and provides lubrication for the bearings for quite a period of time. This motor can run in water once the oil emulsion is lost. But it has the same inherent weakness as the canned motor since the plastic cannot stand excessive heat without swelling and the windings have no salvage value, thus creating costly repairs.

The completely oil filled motor in Figure 32 has many desirable features and probably foremost is the use of oil itself. The motor is completely filled with oil which is always clean and not only provides lubrication for bearings but also prevents corrosion of the motor parts. Oil is a better heat transferring agent than water and permits cooler motor operation.

After factory prefilling, the oil is kept in the motor through the use of a rotary seal which has faces which are lapped to a guaranteed eleven millionths of an inch of being flat. This seal has been proven on countless thousands of submersible installations. There seems to be no questioning of the fact that oil provides better bearing lubrication than water or that an oil filled motor is superior to other types of construction.

The oil filled motor lends itself to different types of internal construction, such as the use of a balance tube, single diaphragm with or without spring loading or a spring loaded double diaphragm. The most recent feature is the spring loaded double diaphragm development shown in Figure 33.

All single phase motors are either of the capacitor start-induction run or are of the capacitor start-capacitor run types. This means that a capacitor is used to get the motor started and almost up to the running speed. At this point a disconnecting switch cuts out the start capacitor and the starting winding which permits the motor to operate only on the running winding as an induction motor. Because of the motor diameter, and other considerations, the motor starting controls are placed in a box and located above ground level.

These are called motor control boxes and include the start capacitor, (and run capacitors in some cases), relay, overload protection and a terminal board. It is very important that the control box be exactly mated to the motor used and that they must not be used for the motor of another manufacturer.

To connect the control box at ground level to the motor submerged in the well water requires the correct size wire to prevent voltage loss and also the insulation must be water resistant. This calls for a three wire, twisted cable with an oil resistant polyvinyl chloride insulation. Each of the wires has a different colored insulation, usually one is red, one is yellow and the remaining wire is black to correctly match the color coded wires on the submersible motor.

Submersibles have advantages not available in other types of pumps, such as:

1) Can be installed at relatively any depth.
2) Can be installed in crooked wells without damage in operation as occurs in plunger and line shaft turbine pumps.
3) Installation is easier and quicker than most other deep well pumps.
4) No well pit or pump house required. A small opening large enough to remove the pump is all that is necessary.
5) Only one pipe used; reduces installation costs.
6) Well can be located at any distance from house.
7) No danger of damage to motor due to floods or seepage as found in some well pits.
8) No priming required.
9) No possibility of air leaks as found in jet pumps.
10) Positive, fool-proof air charging system for pressure tanks. Eliminates all normal water-logged conditions as found in other systems.
11) Quiet operation. These pumps are practically noiseless in operation. Ideal for homes, hospitals and other services where noise must be kept to a minimum.
12) Tamperproof. No adjustments necessary.
13) Maximum efficiency in performance. No other type of pump can deliver as much capacity and pressure for a given horsepower size. The reason for this is there are no external losses, such as gear and plunger rod losses in reciprocating pumps; friction and recirculation loss in jet pumps and line shaft losses in deep well turbines. The submersible pump is a compact direct driven unit that gives minimum losses. All the power can be used to pump water.
14) Lower first cost per gallon pumped than any other pump.

5) Applications.

For 4 inch wells — submersibles are available in ⅓ and ½ horsepower sizes for 115 volt, single phase and ⅓-½-¾-1-1½-2 and 3 horsepower sizes for 230 volt, single phase. The 3 horsepower size is also furnished for 208-220 volt, three phase current. Capacities of over 3,000 gallons per hour, pressures to 345 pounds and well lifts to 800 feet.

For 6 inch wells — submersibles are available in 5-7½-10-15 and 20 horsepower in three phase, 208-220-440 volts and 5 horsepower single phase 208-230 volts. Capacities to 15,000 gallons per hour, pressures to 400 pounds and well lifts to 900 feet.

For shallow or deep wells — wherever cool, clean water is to be pumped on an efficient and economical basis, on farms, in suburban areas, industry and agriculture.

D) Reciprocating Pumps

1) General.

In any consideration of the several types of reciprocating pumps used for pumping water, a division into two basic categories must necessarily be made.

Shallow well pumps are those used to raise water (at sea level) from as much as 25 feet total suction (to include pipe friction) below the pump.

Deep well pumps are those which are used to lift water from pumping levels greater than 25 feet below the pump. Of course, any pump which will raise water from deep wells can also be used as a shallow well pump.

2) Shallow Well.

a) Principle of Operation.

In many instances the shallow well pump is referred to as a piston-type pump and, as the name implies, it is a mechanism in which the piston moves back and forth. The rotating motion of the electric motor is transferred to the reciprocating movement of the plunger assembly through the mechanical linkage of the pump.

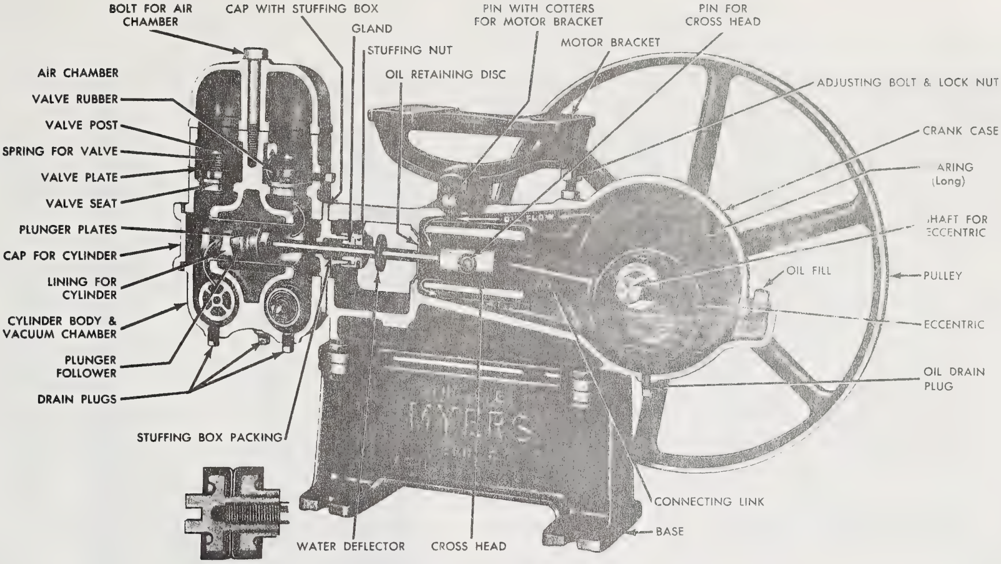


Fig. 34 — Self-Oiling Reciprocating Pump

Figure 34 is a sectional view of a small 400 gallon per hour reciprocating pump. When the plunger moves to the right a vacuum is created in the left end of the cylinder body, and atmospheric pressure on the water in the well drives the water through the foot valve and into the suction pipe, through the suction valve and fills the cylinder. When the plunger moves to the left the suction valve closes and the entrapped water is pushed out through the discharge valve. When the plunger is moving to the left, water again fills the right end of the cylinder. Thus the pump is double acting as it discharges water at each forward and backward movement of the plunger.

b) Performance Characteristics.

The characteristics of all plunger pumps are:

1) Capacity is constant regardless of discharge pressure.
2) Capacity is uniform regardless of suction lift or lift from a deep well.
3) Horsepower varies directly with increase in discharge pressure.
4) Efficiency remains practically constant regardless of capacity, discharge pressure, suction lift or lift from deep well.
5) Discharge pressure limited only by horsepower and pump construction.

Reciprocating pumps, due to design considerations, are usually for comparatively low capacities and high head conditions. The shallow well models are available in capacities to 4000 gallons per hour at pressures to 250 pounds pump pressure.

Economically, these pumps cannot be fitted with one size of electric motor for all installation conditions. From a cost standpoint alone the total head must be determined on each job and the motor size selected as indicated on page 13.

c) Construction Features.

Since the life expectancy of these pumps is 15 years or more, they must be well designed and ruggedly built. They must also be installed so they can be inspected periodically and accessible for adjusting and repairing when necessary.

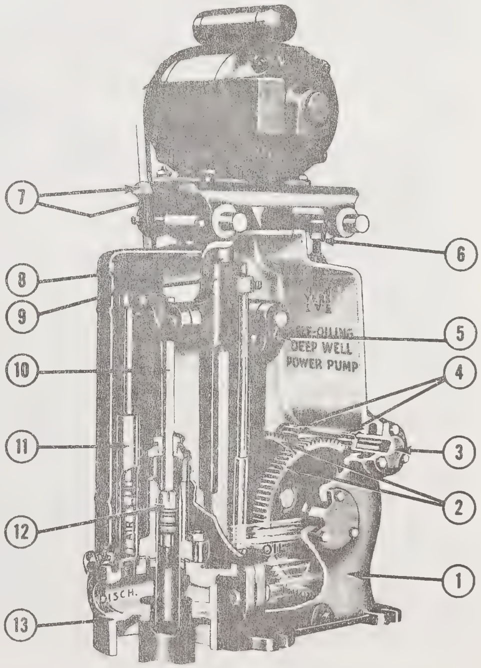


Fig. 35 — Self-Oiling Deep Well Pump

While these pumps are Self-Oiling, it is recommended that the oil be drained and replaced with fresh oil once each year. Simply maintaining the proper oil level does not assure good lubrication. Water can and does get into the oil chamber from condensation and other sources. When this happens the oil floats upward and gives a false impression as to its quantity.

Just a few construction features would be the oversize connecting link and eccentric, oversize crosshead pin, stainless steel piston rod, removable plunger assembly, oversize suction and discharge ports, large and direct waterways, all brass stuffing box assembly and adjustable motor base. These pumps should be recommended where the capacity is constant at a total head within the limitations of the pump.

3) Deep Well.

a) Principle of Operation.

The deep well reciprocating pump, Figure 35, is sometimes referred to as a "working head" because it acts merely as a power unit to operate the pumping barrel or cylinder in the well, force the water where desired and supply air when needed. The most general usage is for securing water from lifts in excess of shallow well pumps.

Years ago these pumps were manufactured in many stroke lengths and for loading to 15 or 20 horsepower. But the submersible type pump has eliminated the large units; some weighed as much as 2000 pounds. The only size now available is the six inch stroke for domestic service, which is limited to a one horsepower maximum load.

Again, with this type pump, the rotating motion of the motor is changed to a reciprocating movement of the piston rod through the mechanical linkage of the pump. The six inch stroke unit operates at 50 SPM and the motor is top-mounted making a neat compact installation.

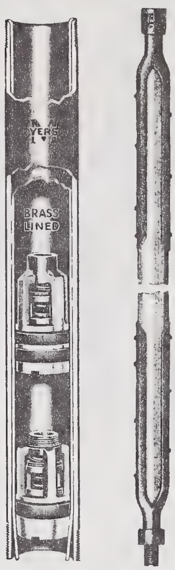
Since it is necessary to lower the pumping barrel down into the well water it is also necessary to provide a drop pipe and a "sucker" rod for attaching the barrel to the pump. For serviceability, the most desirable arrangement is the use of a wood sucker rod and a large diameter drop pipe. See Figures 36 and 37.

It should be noted that both single and double acting working barrels are available. In many instances the double acting barrel is selected because it will pump 65% more water than the same size single acting barrel and uses only 15% more horsepower to do the work.

b) Performance Characteristics.

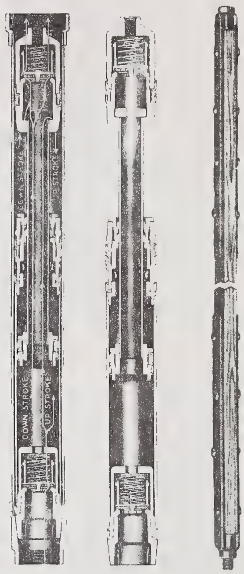
These Self-Oiling deep well pumps have much

SINGLE ACTING TYPE



Octagonal Rod
Fig. 36

DOUBLE ACTING TYPE



Rectangular Rod
Fig. 37

the same characteristics as the shallow well models, refer to page 25, excepting capacities. Maximum capacity would be 480 gallons per hour and 75 pounds maximum pump pressure.

c) Construction Features.

Completely self-oiling, this pump is designed for a lifetime of dependable service. Note the straight upward movement of the connecting link through power applied by double spur cut gears. The pinions are cut integral with the pinion shaft for maximum strength. Back gearing of 7 to 1 assures slow movement of the piston.

Because of its construction, this pump is for installation directly over the well. It cannot be off-set.

THE COMPLETE WATER SYSTEM

The definition of a modern complete water system would be — "A total mechanism designed to automatically bring an adequate amount of water from its source to its points of usage under ample pressure." To conform to this definition, the modern complete water system would consist of an electric motorized pumping unit, a pressure tank, an air volume control, a pressure switch, a relief valve and a foot valve.

A) Pressure Tank (Also see AirGuard Tank Data on page 29).

Two considerations are important when selecting a tank size. The larger the tank the less often the

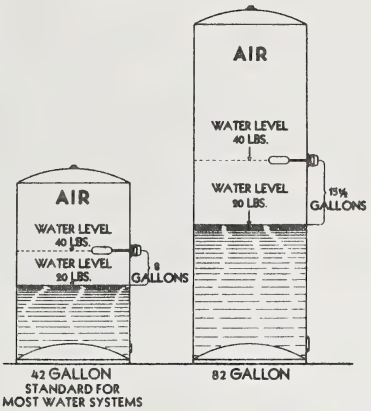


Fig. 38 — Pressure Tanks

pump starts and stops, and the smaller the tank the lower the cost and space requirements.

Since water is not compressible, it is necessary to maintain a supply of air in the tank at all times. This is done through the use of an air volume control, which will be discussed later. The expansion of the compresseed air in the tank drives the water to the points of use.

The amount of air in the tank is important since it determines the amount of water the tank can release before the pump restarts. When a tank contains ⅓ air and ⅔ water at 40 pounds pressure, the tank will release approximately 20% of its total capacity before the pressure drops to 20 pounds and the pump restarts. See Figure 38. On the basis of 200 gallons of water used daily, the pump would come into service about 25 times, when using a 42 gallon tank. This would not be excessive cycling of the system and would keep cool, fresh water on tap.

A pressure tank of too small a size is undesirable from several standpoints, one of which would be rapid cycling of the electric motor causing a high cost electric bill. Another would be extreme wear on the delicate rocker arms and diaphragm in the pressure switch. Another would be a lack of reserve water supply to provide for peak load periods when several water taps were opened at one time. Actually, unless the water system is to be used only for limited service, such as in a summer cottage, the pressure tank should always be of the 42 gallon or larger size.

While galvanized pressure tanks have been standard in the industry for years, a new development in tank coating is now available. This is the "Fire-Cured Epoxy" which makes the tanks corrosion resistant. The Epoxy is used both inside and outside and is bonded tightly for long lasting protection.

B) Air Volume Controls

An automatic air volume control maintains the correct volume of air in a pressure tank and is essential to successful water system operation. Unless the correct amount of air is maintained in the tank it will be water-logged which works a hardship on the motor and controls, the same as a pressure tank of too small a size. Leakage of water at a faucet will then cause the system to start and stop frequently and needlessly.

The amount of air in a tank gradually diminishes, because of absorption of air in the water. If not replenished from time to time the tank becomes filled with water and the air under pressure becomes insufficient to force the water through the pipes. This is a water-logged tank condition.

1) Float Type (Shallow Well)

In operation this control automatically maintains the proper air content in the tank by a float connected to a valve through a diaphragm, see Figure 39. When water in the tank raises the float upward, indicating a need for air, the opposite end of the float rod opens the valve on the outside of the tank and allows the pump to secure air from the atmosphere. This air travels downward through the copper tube, enters the pump body, is mixed with water in the pump and is then forced into the pressure tank.

When the air content in the tank is sufficient, the float never raises and therefore no air will be handled. It should be said that the shallow well controls allow air to be handled only when air is needed in the pressure tank.

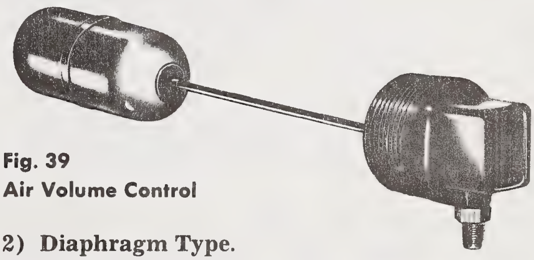


Fig. 39
Air Volume Control

2) Diaphragm Type.

Another air volume control commonly used for both shallow and deep well ejector pump service is the diaphragm type of the floatless construction, see Figure 40. This control dare not be used with reciprocating pumps.

In service a small charge of air is put into the tank each time the pump stops, but only if air is needed. When the tank contains sufficient air no more is added as the air merely works back and forth in the control body. The location of this control is generally lower on the side of the tank because it does not use a float.

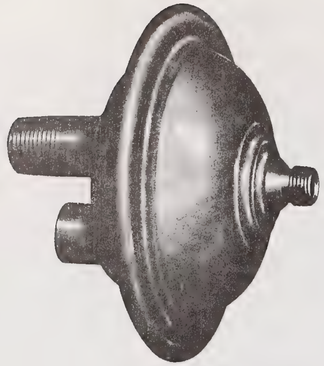


Fig. 40 — Air Charging Control

3) Float Type (Deep Well).
Figure 41 shows the air volume control used on tanks with submersible and deep well reciprocating pumps, or with any pump where a venting type control is needed.

In operation, the proper amount of air under pressure is maintained in the tank by means of the float connected to the shut-off valve, the opening and closing of which is controlled by the position of the float in the tank; and a release air valve, the opening and closing of which is controlled by the air pressure in the tank. When the water in the tank raises the float to its maximum height the shut-off valve is closed. As the water level lowers allowing the float to drop, the shut-off valve opens allowing the air in the tank to pass through the release valve and vent it to atmosphere.

The pressure in the tank at which the release valve will open is determined by adjusting the tension on the spring that holds the release valve to the valve seat. This is usually pre-set to prevent venting air below 30 pounds tank pressure. The release valve spring may be adjusted by the adjusting screw so that air will not escape below a pressure sufficient to force water through the service pipes.

4) Venturi Type Air Control.
A recent innovation for supplying generous amounts of air for pressure tank service with

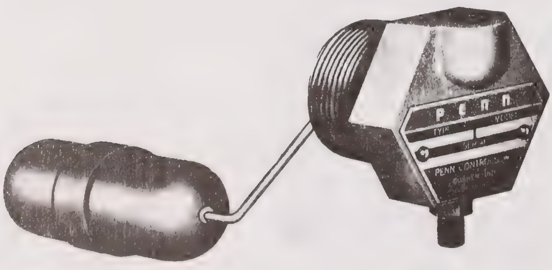


Fig. 41 — Air Volume Control

Ejectos, Submersibles or Centrifugals is the venturi type air charger, see Figure 42. It operates independent of suction conditions, delivers up to 75 cubic inches of free air per minute, operates in a capacity range of from 3 to 50 GPM and handles operating pressures to 60 PSI. There are no moving parts and the control is corrosion resistant.

This charger must be installed in the pipe line between the pump and tank. In operation, water under pressure flows from the pump discharge pipe into the inlet of the air charger. If air is needed in the pressure tank, the water level in the tank will be above the air-level control and the ball valve in the control will close. This prevents any water from flowing into the air charger.

The pressure of the water flowing through the venturi tube in the air charger creates a vacuum which will draw air in from atmosphere through the snifter valve. The air follows the tube into the air charger, mixes with the water and flows into the tank.

If no additional air is needed in the pressure tank, then air from the tank simply circulates from the tank, through the air charger, and back into the tank again.

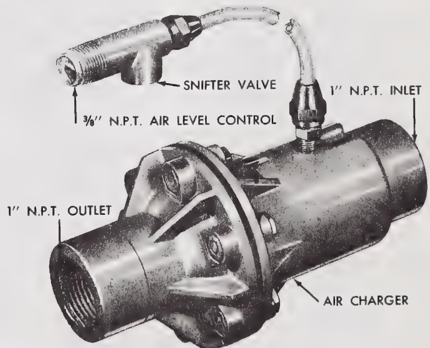


Fig. 42
Venturi Type Air Charging Control

C) Pressure Switch

As the name implies, the pressure switch is a device which opens and closes an electrical circuit in response to changes to the pressure applied to it. This switch controls the operation of the pump. By starting the motor when the pressure reaches a predetermined low point and stopping it after the pressure in the system is built up again, a constant supply of water is kept in the tank at suitable pressures. Usually this is 20 pounds cut-in and 40 pounds cut-out or 30 pounds cut-in and 50 pounds cut-out. The 20 pounds differential between cut-in and cut-out settings is normal.

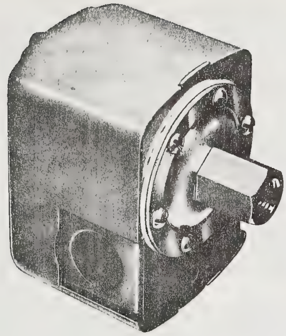


Fig. 43 — Pressure Switch

Figure 43 shows a two pole pressure switch. Mechanically it consists of a pipe flange, a flexible diaphragm, range spring, differential spring, linkage and electrical contacts and connections. A small movement of the rubber diaphragm caused by the pressure against it is multiplied sufficiently by the mechanical linkage to open and close the electrical contacts.

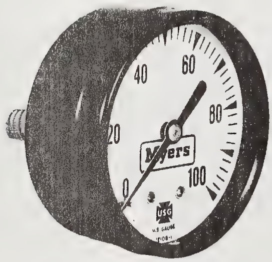


Fig. 44 — Pressure Gauge

D) Pressure Gauge

The pressure gauge is an inexpensive device to indicate water pressure in a complete water system, see Figure 44. With the ejector type system the gauge is properly mounted on the pump case or the pump side of the pressure regulator valve. This aids in correctly setting the minimum operating pressure to make the deep well Ejecto work most efficiently. On most all other types of systems the pressure gauge is mounted on the pressure tank.

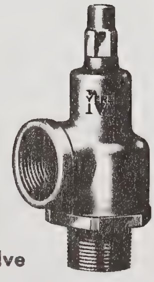


Fig. 45 - Relief Valve

E) Pressure Relief Valve

A relief valve is a spring loaded safety valve with an adjustable spring tension, see Figure 45. It is installed on the discharge or pressure side of a pump. The spring tension is adjusted usually to about 20 pounds higher than the cut-out setting of the pressure switch. If the pressure switch fails to stop the motor at the proper pressure the relief valve will open preventing dangerous pressure in the system.

The relief valve should be manually opened at least once yearly for inspection and assurance of free operation, if and when such operation is necessary.

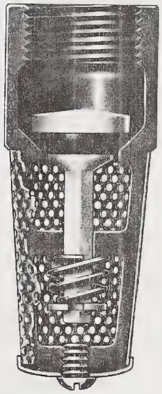


Fig. 46 - Foot Valve

F) Foot Valve.

A foot valve is a combination check valve and strainer used on the submerged end of a suction pipe. See Figure 46. The check valve holds the suction line priming when the pump is not running. The strainer prevents large particles and other foreign matter from entering the suction pipe.

The strainer on the foot valve is not designed to keep sand from entering the suction pipe. A mesh screen small enough to exclude sand would plug up quickly and prevent water from entering.

In the case of a driven well, where the well diameter is small, the check valve less any strainer is used to maintain priming.

G) AirGuard Float-Type Pressure Tanks

As discussed previously, millions of pumps have been installed with pressure tanks fitted with air volume controls. The sole purpose of the air volume control is to automatically maintain sufficient air in the pressure tanks to allow adequate water pressure where and when wanted and to also prevent too frequent starting and stopping of the pump due to water logging of the tank.

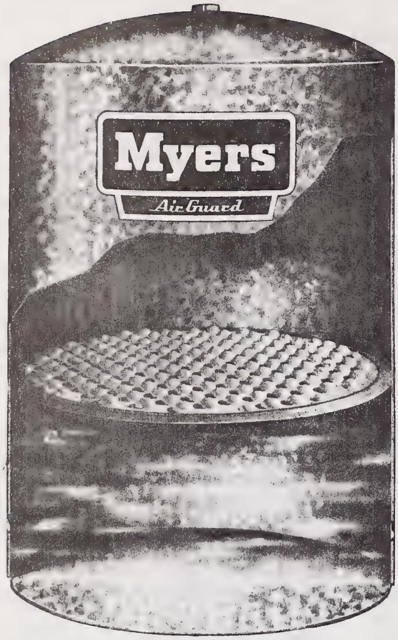


Fig. 46A — Float-Type Pressure Tank

Several causes of water logged pressure tanks are:

1) **Air being under pressure in the tank becomes absorbed into the water**
2) **Mechanical failure of air pumping equipment due to normal use or unfavorable water conditions.**
3) **Average operating pressure on jet pumps can be exceeded and prevent air pumping cycle from occurring when needed.**
4) **Flooded suction conditions on shallow well installations.**

The Myers AirGuard Tank, shown in Figure 46A, comes fitted with a semi-rigid float which will control water logging. This air-water barrier floats on the water surface, rising and lowering with the water level in the tank.

The float keeps the tank water and air separated, one from the other, controlling air absorption into the water. Also the float has a wiping edge which prevents air absorbing water from collecting on the tank wall in the air chamber, as the float lowers.

There is no mechanical air volume control to mal-function or fail.

When used with jet pumps, the required average operating pressures, for deep well installations, can be raised to reduce pump capacities on low yield wells. This procedure would normally prevent air handling and cause water logging when done with a tank fitted with an air volume control.

Extremely short suction lifts with shallow well pumps, or when water actually flows to the suction side of shallow well pumps, requires that a restricting valve be installed in these suction lines in order that a vacuum will be developed. A restriction is not needed in a suction line when the AirGuard Tank is used.

Another feature of the AirGuard Tank is that iron, common to many waters, cannot readily oxidize in the tank as the water does not contact the air.

Figures 46B and 46C show two different methods of using the AirGuard Tank. Figure 46B is the "floated" method which has gained acceptance in some areas.

But the AirGuard Tank, see Figure 46C, can also be installed in the usual way where the water enters one side of the tank and is released thru the other side. This is very desirable when the well water must be chlorinated and provides retention contact time for the chlorine and water in the tank.

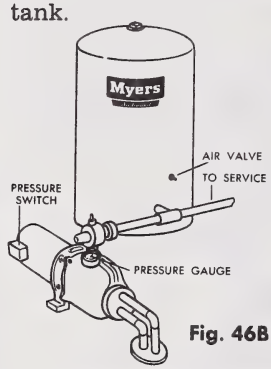


Fig. 46B

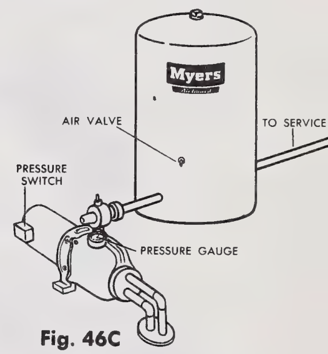


Fig. 46C

Another very important feature available with the AirGuard Tank is the pre-charging benefit. By initially placing a super charge of air in the tank much more water can be used from the tank before the pump again starts. Note the following Table, Figure 46D.

Pre-charging is recommended as it will greatly increase the efficiency of the entire system by draw-off and increase pump and control life.

USE THESE CHARTS TO PRE-CHARGE TANKS
DRAW-IN GALLONS PER PUMP CYCLE

		42 Gallon	42 Gallon Squat	82 Gallon
20-40 P.S.I. SETTING	Atmospheric	6.4	6.7	13.0
	5 p.s.i. Precharge	8.7	9.0	17.6
	10 p.s.i. Precharge	10.8	11.3	21.9
	15 p.s.i. Precharge	13.1	13.0	25.5
30-50 P.S.I. SETTING	Atmospheric	4.3	4.5	9.1
	5 p.s.i. Precharge	5.6	5.9	11.2
	10 p.s.i. Precharge	7.1	7.4	13.9
	15 p.s.i. Precharge	8.6	8.9	16.7
	20 p.s.i. Precharge	9.9	10.5	19.6
	25 p.s.i. Precharge	Not Recommended	Not Recommended	22.5

Fig. 46D

SELECTING THE COMPLETE WATER SYSTEM OF ADEQUATE CAPACITY

The first requirement of any water system is to provide enough capacity to meet both present and future requirements. People should grow into their water system and not out of it. It is considered unwise to install a system to meet only present water needs since National figures show a per capita increase in water consumption every few years.

But it would also be unwise to install a pump rated in excess of the ability of the well to produce. Knowledge about the well diameter, total depth, its yield and pumping level must be available.

As enumerated in the opening section of this Manual, water is necessary for bathing, fire protection, dish washing, laundry, cooking, lawn sprinkling, car washing, and many other uses, but not necessarily in this order of importance. A lack of sufficient pump capacity (5 GPM at 30 PSI) for limited fire protection is many times overlooked.

Unless the well flow is less than 5 GPM, this amount of water should be an absolute minimum for any water system. Preferably, the system capacity should be from 8 to 10 GPM which is more in line with the recommendations of the Underwriters. Usually the difference in cost between a low capacity and an adequate capacity water system is only $25.00 to $50.00.

It would be difficult to set up a formula that would arrive at adequate capacities for all installations, but a time proven rule, based on the estimated daily requirements and the fact that 80% of the water used in a home is during a two or three hour period, works very well. The following table gives the average quantities of water per day needed for the different services demanded of a water system.

Each member of the family, for all purposes, including kitchen, bath, laundry	50 gal.
Each horse	12 gal.
Each milk producing cow	35 gal.
Each hog	4 gal.
Each sheep	2 gal.
Each 100 chickens	4 gal.
One hour of lawn sprinkling, garden irrigation, flushing, etc.	300 gal.

Use the foregoing table to arrive at the daily needs for water for a typical farm installation; 6 members of the family, 5 horses, 10 milk producing cows, 30 hogs, 200 chickens and one hour lawn sprinkling.

The family will need	300 gal.
Horses	60 gal.
Cows	350 gal.
Hogs	120 gal.
Chickens	8 gal.
One hour hose use	300 gal.
Daily need	1138 gal.

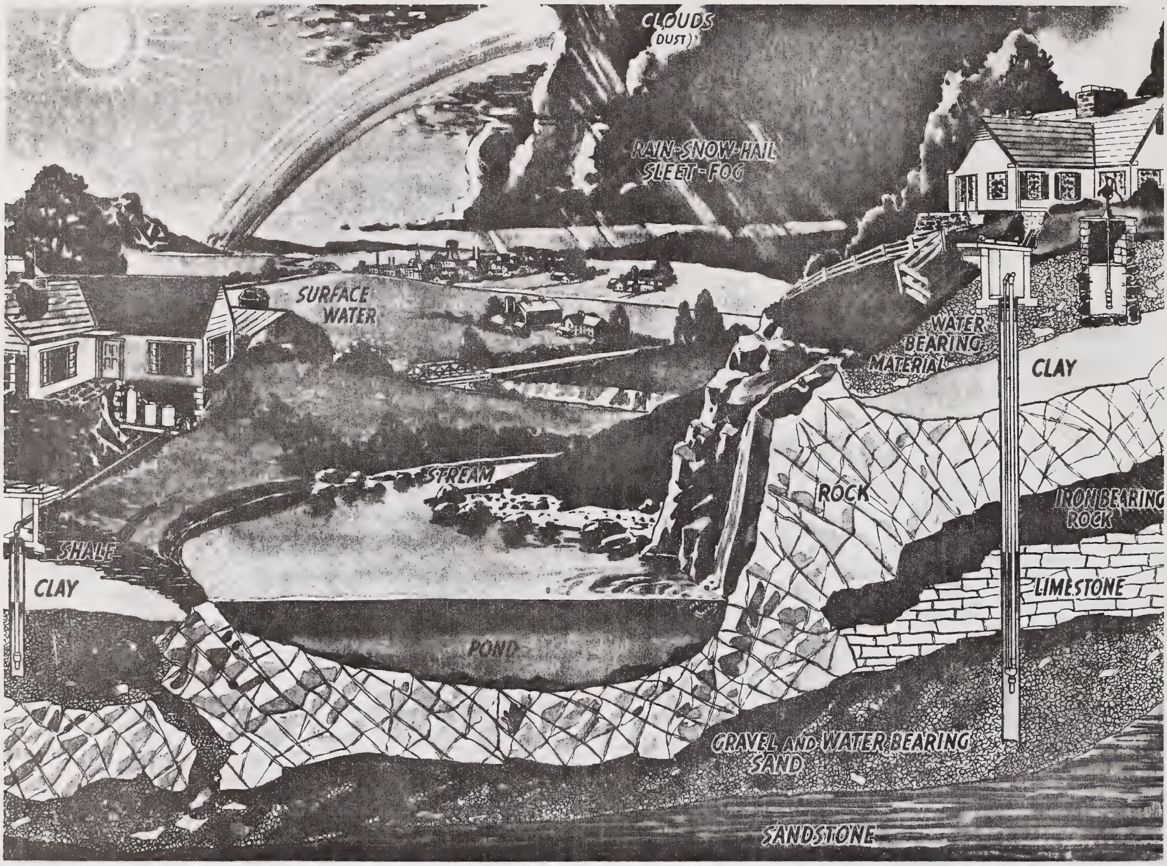
In order to arrive at the pump capacity, divide the above total by two. ($1138 \div 2 = 569$). If the well will yield 10 GPM or more, the pump capacity should be from 9 to 10 GPM. Now look ahead and add in any additional water needs for the next 10 years or more. The result will be a properly selected water system.

Obviously, the foregoing method will not serve correctly for a non-farm home. To select proper pump capacity, the peak load for water should be the governing factor. How many outlets will be open at one time?

The one bath room home, with water in the kitchen, laundry and outside sill cock, should never buy a water system with less than 8 GPM capacity. It requires about 5 GPM for a tub or shower bath, and with 8 GPM this would leave 3 gallons available for use in the kitchen. A two bath room home should have from 12 to 15 GPM available; else there will be a shortage of water under peak load conditions.

Entirely too many prospective water system users do not realize the importance of an adequate capacity water system. They think of a 3 or 4 GPM pump which will supply 180 or 240 GPH or 1800 to 2400 gallons in 10 hours time. They feel that this is more water than they can use. They lose sight of the fact that the 3 or 4 GPM pump will supply only one outlet and that other outlets will be starved.

As was said earlier in this Manual, it costs no more to pump a given amount of water with a larger system than with a smaller one. And because the larger unit need not run so long each day or year, the maintenance will be less. So select an adequate capacity system each time.



Water Cycle Illustration

ALL WATER NEEDS CONDITIONING

If water as it occurs in nature was pure water, and nothing else, there would be no need for water conditioning. Whatever the source, however, water always contains impurities in solution or suspension. It is the control of these impurities that makes water conditioning essential.

What are some of these impurities? They can be many and depend upon the source of the water such as rain water, surface water or ground water. Pure water is tasteless, colorless and odorless and is one of the most universal solvents, that is, more things dissolve in water than in almost any other liquid. Because pure water is such a good solvent it presents water problems.

Each second, 16 million tons of water are being precipitated in the world and a like amount is being evaporated. The above illustration shows the water cycle as a continual precipitation/evaporation process.

CONVENIENCE OF CONDITIONED WATER IN THE HOME

1) Cooking and Drinking.

a) **Green vegetables,** when cooked in hard water, absorbs the hardness minerals and causes shrinkage and they become tough and inedible. This is noticed particularly in peas, beans and other legumes.

b) **Hard water** robs canned (and other boiled) foods of their natural flavor and color. The National Canners Association recommends completely softened water for canning.

c) **Use only softened water** to brew truly good coffee and other delicious beverages. The scale in metal perculators is a deposit of hard water salts which retains some of the fat from the coffee grounds, eventually becomes rancid, and detracts from the coffee flavor.

2) **Personal Grooming.**

a) **The dull film** which cannot be washed off the hair is caused by the sticky curd produced by hard water. Under this condition hair loses its lustre by as much as 60%. The hair thus dulled eventually becomes brittle and loses its wave, even if it is a natural wave.

Soft water leaves the color and texture as it was meant to be — soft and fluffy, yet easily managed with natural color and lustre. The hair also dries faster. Soft water keeps the skin smooth and fresh and free of roughness.

3) **Laundering in the Home.**

a) **Since no precipitates** will form during the washing of clothes in soft water, the clothes will look and feel cleaner and softer than they ever were before. No precipitates will form during the rinse cycle either; thus a cleaner, evener ironing with the use of modern starches will result.

b) **The life expectancy** of fabrics will be increased as much as 50% when using soft water, depending on the hardness minerals that were formerly present. In an effort to eliminate tattle-tale gray, the hard water user will wash more frequently with stronger and harsher agents. It is a known fact that fabric life is directly related to the number of launderings.

c) **The savings** on soap and detergent alone could be $20.00 yearly, depending on the prior hardness of the untreated water.

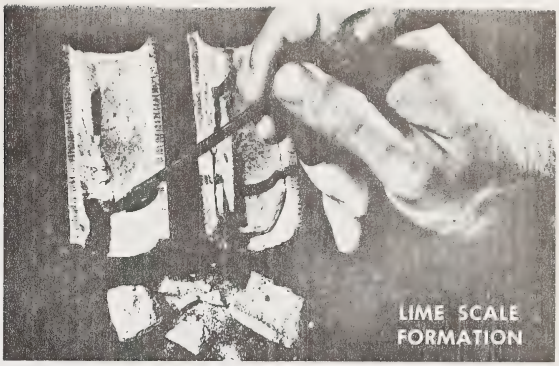
d) **Soft water** leaves baby's things soft and sweet smelling. Many a case of diaper rash has been cleared up by just switching to soft water laundering of diapers and bedding, because this will eliminate the hardness which can scratch and irritate baby's tender skin.

4) **General Cleansing.**

a) **The unmentionable bathtub ring** is gone forever when soft water is used. With soft water there is no scale or grime to remove from tubs, basins, etc.

b) **What operation** in the kitchen consumes more of the housewife's time than dishwashing? Transparent glassware presents a challenging problem whenever hard water is used. The filmy, streaky appearance is caused by grease and soap scum which hard water cannot wash away. This condition exists regardless of the washing method employed — hand or machine, air dry or wiping.

Dishwasher manufacturers will be quick to say that only with properly conditioned water can your machine give its best performance. Hard water not only affects the cleanliness of the table ware, but also can scale and clog the machine itself, leading to mounting maintenance expense.



Typical Loose "Scale" Mainly Calcium and Magnesium Carbonated in Water Heating Piping.
Fig. 47

Why can't hard water get the cleaning job done properly? This is due to the hard water already being loaded with chemical impurities.

5) **Heating and Plumbing.**

a) **When hard water is heated,** the calcium and magnesium minerals in the water are converted to another less soluble form. These salts come out of the water as solids and gradually build up a layer of hard scaly material on the inside of pipes and other equipment through which the water passes. See Figure 47 for a cross-sectioned piece of hot water pipe.

b) **As little as ⅛" of hard water scale** in water heater coils can boost heating bills as much as 16 cents out of each dollar and reduce heating efficiency by more than 20%. This scale also acts as an insulator which, rather than passing heat along to the water, develops hot spots which actually destroys the pipe. The build-up also creates friction losses and a pressure drop in the house; sometimes a complete stoppage.

These costly conditions can be prevented by simply softening the water.

6) **Miscellaneous Uses.**

a) **Cleansing of dairy equipment** is much easier when the use of soft water eliminates milk film, the chalk-like residue formed when dried milk combines with calcium and magnesium in hard water.

The Dept. of Agriculture limits the maximum permissable fruit spray residue (arsenic, lead and chlorine compounds) on produce shipped in interstate commerce. Soft water makes removal of this residue an easy matter.

b) **There are many water using devices** in the modern home which simply cannot operate at the designed efficiency without properly conditioned water. These include steam irons, humidifiers, some types of air conditioning, etc. These units require completely mineral free (not only soft) water.

UNCONDITIONED WATERS

The various sources of unconditioned waters can be conveniently classified as:

1) Rain water . . . cisterns.
2) Surface water . . . brooks, creeks, rivers, ponds, lakes, reservoirs.
3) Ground water . . . springs, deep wells, shallow wells.

Now let us look at each of these three classes of water.

a) Rain Water.

Water precipitated from the atmosphere, high above the earth, is chemically pure. However it does not remain pure very long since, as mentioned earlier, water is one of the universal solvents. It will dissolve a little of everything with which it comes in contact. As water descends through the air, oxygen, nitrogen and carbon dioxide (the normal gases present in the atmosphere) are dissolved in the falling water. Rain water also encounters dust, smokes and fumes which are dissolved or retained in suspension. Bacteria in the spores of microscopic organisms may be picked up.

b) Surface Waters.

Water obtained from surface streams, ponds, etc. may be turbid by the presence of clay and silt. Agricultural land may contribute to the organic matter and may pollute the water with animal waste. Swamps may discharge their waters during floods and carry decay and vegetable matter, color and microscopic organisms into the streams and ponds. In addition, surface waters are exposed to pollution by animals and humans, the sewage of cities, and the waste of industry. Usually surface waters do not contain as much hardness or other minerals as does ground water, since they usually are not in contact with rock formations.

c) Ground Water.

Rain in descending through the air and percolating through the upper layers of soil, absorbs carbon dioxide with which it forms carbonic acid. This action increases the solvent power of the water so that it dissolves a certain amount of the mineral matter of the soil or rock with which it comes in contact. The rock and sand in the soil are made up of many kinds of minerals and chemical substances. Each area contains different rock formations so the nature and kinds of impurities will vary in different sections of the country. The most common minerals are limestone, and dolamite, a natural rock containing calcium and magnesium, the hardness particles. The quantity dissolved depends upon the length of contact and solubility of the materials.

Deep well waters are usually clear and colorless due to the filtration taking place through the layers of rock and sand. Usually shallow well waters will not contain as high an amount of hardness or other dissolved minerals as the deep well. Shallow wells may at times be turbid, especially after heavy rain. Spring water is usually similar in characteristics to water obtained from shallow and deep wells in the area.

The impurities that may be present in a water supply can be divided into suspended and dissolved solids. Suspended solids are those which do not dissolve in water and which can be removed or separated by filtration. The presence of hardness in a water supply is an example of dissolved solids. Gases may also dissolve in water, but unless they combine chemically with other impurities also in solution, these gases will be expelled from the water on boiling and are not considered as dissolved solids.

HARD WATER

Hardness is the most common impurity in water. It is defined as calcium and magnesium salts, such as lime, gypsum, epsom, in solution. Water hardness is the result of water's ability to dissolve and hold in solution, compounds of calcium and magnesium, which have been absorbed from limestone deposits in the earth's crust. While it is true that all water supplies are not extremely hard, it is also true that there is almost no water supply which is absolutely soft.

The Hardness Map, Figure 48, indicates that approximately 85% of the United States can be classified as hard water areas. The other 15% have other problems such as corrosion and iron.

What is hard water to various people? To the housewife, it is the soap curd, the ring around the bathtub, and it makes laundering and cleaning difficult. The curd adheres to cloth fibers, glassware and dishes. To the man of the house, it means scale in the water heater which runs up the fuel bills. It clogs pipes and reduces water pressure. To the laundry operator, it is water that requires extra amounts of soap to produce working suds. It leaves a gray scum on the wash and in the wash wheel. To the chemist, it is water that contains an appreciable concentration of calcium and magnesium.

The calcium and magnesium salts in their relative average abundance in various water supplies are (1) carbonate (2) sulphates (3) chloride and (4) nitrates. The carbonates are by far the most

abundant. Usually calcium salts are about twice as abundant as magnesium salts. As soon as the carbon dioxide in the water comes into contact with the limestone, a chemical reaction occurs and calcium carbonates and magnesium carbonates are formed.

Hardness is measured in terms of grains per gallon (gpg), as its calcium carbonate equivalent, or parts per million (ppm). To convert from parts per million to grains per gallon, divide by 17.1. In other words, 1 gpg is the same as 17.1 ppm. Most water analysis forms will show hardness as grains per gallon as this is the value used in figuring capacity and size of softeners. The most commonly used term is "grains hardness."

In 15% of the areas shown on the Hardness Map the hardness is 3.5 gpg or less. It is hardly worthwhile reducing this hardness to zero. It is difficult to show much benefit from such water when the water is this near to zero hardness. The areas where softeners are needed are where the hardness is over 7 gpg. It is usually not economical to soften waters with hardness over 100 gpg.

IRON IN WATER

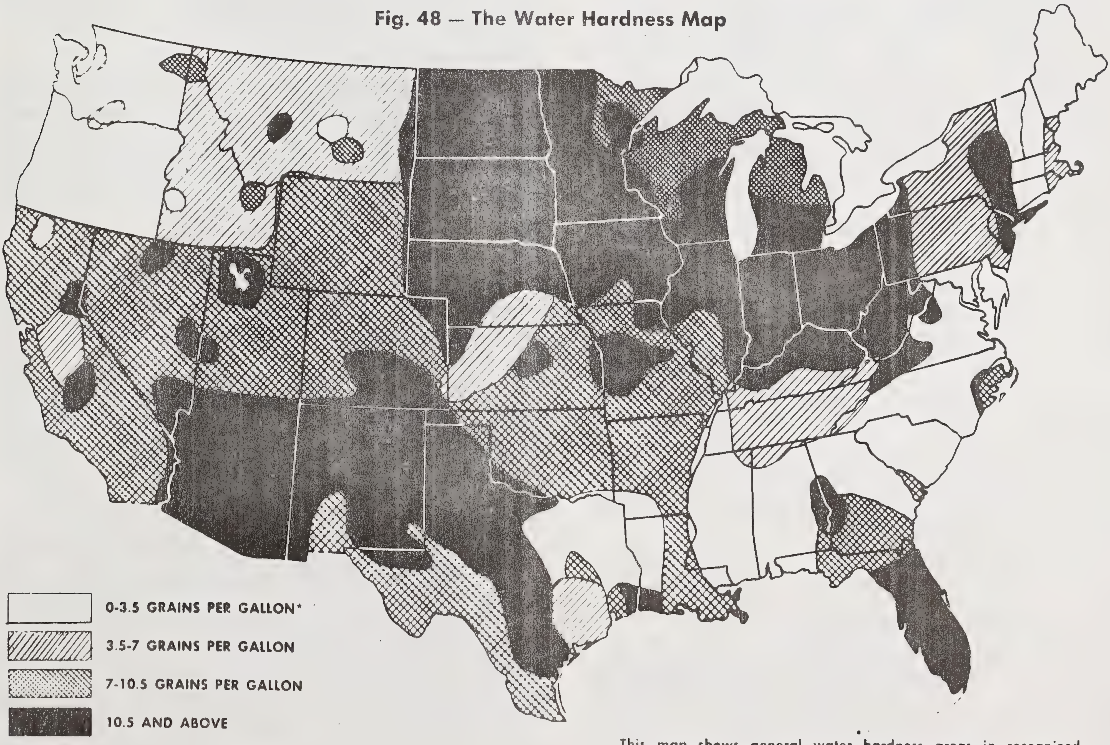
Iron in water is extremely undesirable as it tends to discolor everything it touches. It is one of the most common elements found in the earth's crust and is generally found in two forms. One is iron oxide and the other is iron bacteria.

Iron in nature usually occurs as an insoluble oxide. When conditions of the earth are favorable, the iron is converted to a soluble form and is then dissolved in waters with which it comes in contact. For this reason iron is found present to some extent in almost all of our natural water supplies, particularly in well waters.

Chemically, iron can be visualized as occurring in water in both ferrous oxide and ferric oxide. In the ferric state the iron is completely oxidized, whereas in the ferrous state it is only partially oxidized. Ferrous oxide is soluble and hence colorless and ferric oxide is completely insoluble and red in color causing the familiar red stains.

In surface waters iron is in the ferric state but in well waters it is usually in the ferrous form. Upon removal from the well, and exposure to air

Fig. 48 — The Water Hardness Map



This map shows general water hardness areas in recognized variations. However, due to the nature of the water bed sub-soil structure, water hardness may vary from one source to another within a general area.

and release of carbon dioxide, the iron in the water is converted to the ferric state.

Iron bacteria are living organisms that feed on the pump, piping, tank and iron fixtures causing damage and adding to the actual iron content of the water. They also build slimes on tanks, toilet water closets, etc.

From this it is easy to see that iron occurs in many forms and in varying amounts, and it is impossible to establish one specific method of conditioning the iron bearing water. When iron is present in an amount exceeding 0.3 ppm, it is usually considered objectionable for both industrial and municipal supplies. The U. S. Public Health Service Standards recommend a limit to the iron content in acceptable drinking water to 0.3 ppm. There is no evidence to prove a greater amount is physically harmful, but this limit was based upon the appearance and taste of the water.

The iron content of the great majority of iron bearing well waters will be found in the range below 5 ppm, a few in the range from 5 to 15 ppm and a very few above this.

a) How To Correct Iron In Water.

1) Water Softener.

The simplest method of removing iron in solution from clear water, if the upper limit does not exceed 3 ppm, is by using a water softener. Such iron is usually in the form of ferrous bicarbonate and is exchanged for sodium bicarbonate in exactly the same manner that hardness is removed.

What makes iron so troublesome on well jobs is the fact that while the iron is usually in complete solution as ferrous bicarbonate as it comes from the well, it comes in contact with the air under pressure in the pressure tank. This further oxidizes part of the iron before it reaches any filter or softener that follows.

A softener will filter suspended iron including ferric iron but must be thoroughly backwashed and cleaned regularly. The ferric or oxidized iron will tend to foul the softener bed and will bleed iron through. Since iron is heavier than the softener mineral, the job of backwashing the iron out becomes very difficult.

A water softener, then, can be used to remove small amounts of iron that are in solution.

2) Manganese Zeolite Filters.

The principle of operation of a manganese zeolite filter is to oxidize the iron to precipitate it and then filter it out in the same unit. The mineral bed contains manganese dioxide (in manganese green sand) which converts the ferrous oxide to ferric oxide, thus precipitating the iron.

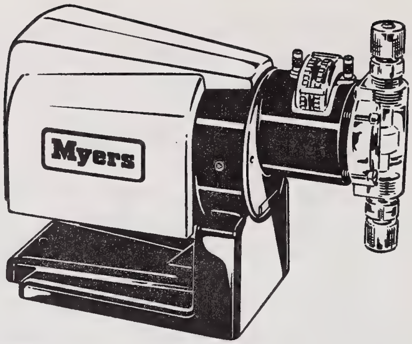


Fig. 49 — The Chlorinator

The oxygen in the filter is replenished by putting in potassium permanganate. These filters will remove iron in the ferrous or ferric states up to a maximum of about 10 ppm of iron. They will not remove organic iron or iron bacteria.

3) Chlorination

A chlorinator, see Figure 49, should be used when iron bacteria or organic iron are present. In addition, a chlorinator will also oxidize the ferrous oxide. Then a slow sand filter is necessary following the chlorinator to filter the iron from the water. By using a chlorinator and a sand filter, all types of iron can be removed.

4) Polyphosphate.

Chemicals in the polyphosphate family have the ability to keep low concentrations of iron in solution. As long as the iron remains in solution the water will remain clear and no stains will occur. The polyphosphate will not effect iron that is already precipitated — it will go on through the system as red staining water. This chemical can be thought of as wrapping itself around the iron so that it will not pick up any additional oxygen from the water, pressure tank, or air as it comes out of the faucet.

It will keep the water clear for drinking, but it may not entirely prevent iron from precipitating when water is boiled for a considerable length of time.

5) Summary.

1) If iron, ferrous or ferric, is not over 3 ppm, use a softener only.
2) If ferrous and/or ferric iron is between 3 and 10 ppm, use a manganese zeolite iron filter.
3) If ferrous and/or ferric iron is above 10 ppm, use a chlorinator and sand filter.
4) For any amount of ppm of organic iron, use a chlorinator and sand filter.
5) For iron bacteria, use a chlorinator and sand filter.

SULPHUR IN WATER

"Sulphur water" as it is called is primarily hydrogen sulphide dissolved in water. Hydrogen sulphide imparts a characteristic "rotten egg" odor and taste to the water. It will combine with other impurities in the water to form iron sulphide or black water.

Waters containing 1 ppm or more of hydrogen sulphide are definitely objectionable. Waters containing less than 0.5 ppm usually are not. Generally hydrogen sulphide concentrations are below 10 ppm but occasionally waters are found which contain 50 to 75 ppm.

Hydrogen sulphide may be present naturally in a water supply but is usually caused by certain types of bacteria in the water table. Sulphur may also be in the water from contamination from mine fields. Usually it is caused by bacteria reducing the sulphur.

With the exception of those enterprizing commercial establishments who bottle it or operate sulphur baths, the majority of people with sulphur water in their homes are extremely anxious to get rid of it. With sulphur water, coffee, tea, ice cubes and cooking suffer substantially. It even turns some liquors black.

Hydrogen sulphide is very corrosive and will eat away pump parts, piping, tanks, water heaters, fixtures and anything of iron, steel, or copper alloys. In many instances it ruins paint and wallpaper. Silverware turns black almost instantly. Even if the home owner did not mind the taste and odor, it can be extremely costly and should be eliminated.

HOW TO CORRECT SULPHUR IN WATER

There are three main methods of removal or partial removal of the sulphur problem.

a) Aeration.

Aerators mix water with air to provide oxygen atoms to precipitate the sulphur. They must then be followed by filtration. Aeration is only recommended on consideration of maximum sulphur, proper pH control, and equipment limitations.

b) Manganese Zeolite Filters.

This is the same unit discussed under iron removal. It has an upper limit of about 5 ppm of sulphur, it will do a good job if properly operated. The completely oxidized sulphur is tasteless, odorless, colorless, and non-corrosive, so that it causes no problems.

c) Chlorination.

The best, most widely practiced method with small water systems is the use of automatic chlorination. The chlorine chemically oxidizes the hydrogen sulphide, iron sulphide, and the other sulphides, thus eliminating them completely. The chlorine also kills the sulphur bacteria and any disease bacteria present. The result is safe, sulphur free water Because sulphur content varies and reasonable chlorine residues are required for bacteria kill in small water systems, it may be necessary to dechlorinate the water for household use.

It is important to remember that it is the chlorine that kills the sulphur problem, so that there is no "rotten egg" odor or taste, no sulphur corrosion, no black sulphur water in the house. Dechlorinating filters contain carbon which will absorb the excess chlorine and thereby eliminating all odor and taste.

Activated carbon will also absorb hydrogen sulphide in small quantities. The main difficulties with this filter in eliminating all sulphur problems is the small quantity it will remove, and also the carbon cannot be regenerated, so that once it is used up, all the carbon must be removed and replaced. This method of sulphur removal is not recommended and is only mentioned to arm the reader in case someone in your area is trying to sell this equipment for sulphur removal.

ACID AND CORROSIVE WATERS

Water is either acid, neutral or alkaline in nature.

To denote its nature, an artificial symbol, pH has been established. The pH scale is a measure of acidity and alkalinity, Figure 50. Therefore, pH is a number between 0 and 14 indicating degrees

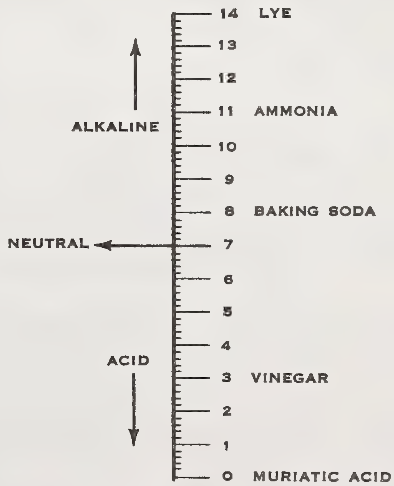


Fig. 50 — pH Table

or acidity or alkalinity. Neutral water has a pH of 7. Values below 7 and approaching zero are increasingly acid while values from 7 to 14 are increasingly alkaline. In addition to this important relationship, one other point must be kept in mind: each pH number indicates 10 times greater strength as it varies from 7, because the scale is logarithmic. For example, water at a pH of 5.0 is 10 times more acid than a pH of 6.0 and a pH of 4.0 is 100 times more acid than a pH of 6.0. Similarly a pH of 9.0 is 10 times more alkaline than a pH of 8.0.

Examples of an alkaline solution are baking soda with a pH of about 8, washing soda and ammonia with a pH of about 11, and lye with a pH of about 14. Examples of acidic solution are vinegar with a pH of about 3 and muriatic acid with a pH of about 1.

Acid water as referred to in well waters is water containing carbon dioxide. The presence of carbon dioxide in water is caused by the decay of organic matter, absorption from the air and ground by the rain water as it falls and then passes through the ground to the water table.

The pH value of most natural waters will fall within the range of 6.0 to 8.0, although more acid conditions and lower pH will result where the water contains high concentrations of free carbon dioxide or acid mine drainage. pH values above 8.0 are seldom encountered except where solutions by alkaline industrial waste exists or where the water has been chemically treated such as by the lime soda process. Acid waters are commonly found in those areas where the hardness content is below 3½ gpg. From the Water Hardness Map shown this means 15% of the United States contains acid water. However, acid waters are also encountered in other areas of the country.

The acid water will corrode or eat away metal components of the water system including the pump, piping, tank, water heater, and fixtures resulting in costly leaks and equipment failure. Acid waters will attack copper piping and plumbing causing a blue or green stain on fixtures and on clothes. It will attack galvanized piping and tanks thereby causing red stains on fixtures and clothes.

In addition to causing corrosive damage to the water system, acid water may prevent complete precipitation of iron before filtration. Iron will not oxidize readily in acid water. Therefore, in iron removal by a manganese zeolite filter or by chlorination, it is necessary to also correct for pH. In correcting acid water when iron removal is being performed, it is advisable to raise the pH at least to neutral or over.

HOW TO CORRECT ACID AND CORROSIVE WATERS

Mainly two methods are available to raise the pH of small water systems.

a) Neutralizing Filters.

Elevation of the pH by passing the water through a filter bed of limestone chips has been used with moderate success. These chips are calcium carbonate and combine with the carbon dioxide in the water and thus raise the pH. Some of the calcium carbonate will dissolve into the water and increase the hardness. The removal of all the carbon dioxide produces what is known as as unstable water, which means it is supersaturated with calcium bicarbonate and thus precipitation of calcium carbonate beyond the neutralizing filter can easily occur. The disadvantage of the increase in hardness is overcome by a water softener installed following the neutralizing filter.

b) Soda Ash Feeding.

The most satisfactory way of eliminating the acid water problem is by feeding soda ash solution into the water automatically whenever the water pump is running. It is best to feed this solution through a small tube down the well to the end of the pump drop pipe (or to the pump itself in the case of a submersible pump) or into the pump suction pipe to provide protection of the pump and its piping.

Soda ash (formula Na_2CO_3) is a highly alkaline compound used in water treatment by many municipalities. The soda ash chemically combines with the acid water to completely neutralize it. Thus the soda ash feeder can be adjusted to feed the correct amount to raise the water to whatever pH is desired. The important advantage of soda ash feeding is that it can be accomplished together with automatic chlorination equipment without raising the hardness. Thus the automatic chlorinator will chlorinate for safe water (and iron or sulphur precipitation where applicable) **and** soda ash feed to eliminate the acid water problem simultaneously.

TURBIDITY, SUSPENDED MATTER AND COLOR IN WATER

Turbidity is a measurement of the obstruction of light passed through a water. Suspended matter is the quantity of material in a water which can be removed by filtration. A water may be dark in color but still clear and not turbid. Turbidity, or suspended matter, can be said to be the lack of clearness or brilliance in a water which should not be confused with color.

Turbidity and suspended matter may be in the form of oxidized iron, fine sand, clay, organic matter or microscopic organisms. Water taken from a river or turbulent stream usually contains appreciable quantities of turbidity. The water from lakes and ponds generally is less turbid because of the settling action which takes place in these bodies. Springs and wells are usually low in turbidity because of filtering action of the ground through which the water flows.

Color in water may originate from coal or peat seams, swamps, and iron bearing strata. Color in natural water is found generally to be due to the presence of tanin in solution, (from decaying vegetable growth) or from various industrial wastes. Waters usually vary from colorless to a deep brown.

These problems are easy to recognize since you will either see suspended matter in the water or else the water will have a distinct color. The U. S. Public Health Service drinking water standard recommends that the turbidity of drinkable, or potable water be less than 10 ppm as silica. They also recommend that the color of potable water be less than 20 standard units. These standards indicate the degree of color intensity.

a) How to Correct Turbidity, Suspended Matter and Color in Water.

Turbidity can be removed by a conventional sand filter in most cases. If the suspended matter will not settle out, applications of filter alum will coagulate the fine suspended matter and may be necessary prior to filtration. Filter alum is applied by means of a jug or alum type feeder. This coagulation will enlarge the particles so they will be retained on the filtering medium of the sand and gravel.

Chlorination followed by activated carbon filtration is the most common method of removing color from household supplies.

TASTE AND ODOR IN WATER

Taste is a relative problem because it involves individual preference. Although taste and odors may have no bearing on the hygienic safety of a water supply, they can, when sufficiently strong, make it exceedingly distasteful. In any event, it is a good plan to have a bacteriological examination made by the local or state board of health.

Taste in water is caused by organic matter, dissolved gases, and/or minerals. A bitter taste may be due to the presence of iron, manganese, large amounts of sulphate, or excess lime. Waters containing a large amount of sodium bicarbonate are often described as faintly inky tasting or sometimes soapy. Waters containing an unusual quantity of salt, will have a brackish taste.

Sodium salts are commonly found in most water supplies along with those of calcium and magnesium. These natural salts exist in large amounts in the earth's surface, and the kind and amount in a particular water will depend on the composition of the ground over which and through which it flows. Sodium chloride or common salt in large enough quantities may give a salty or brackish taste to the water. Sodium sulphate, or glauber salt, may have a laxative effect if present in large amounts.

Objectionable odors are many. They may be due to microscopic plant and animal organisms, decaying organic matter, dissolved gases, (including hydrogen sulphide and sulphur dioxide), waste from industrial plants, and chlorine used for disinfection.

HOW TO CORRECT TASTE AND ODOR IN WATER

An activated carbon filter is the most practical remedy to removal of taste and odors. However, it is not applicable for the removal of salt from water or for the removal of large amounts of hydrogen sulphide. Salty or soda taste caused by excessive dissolved minerals can only be corrected by reducing the concentration either by distillation or demineralization. There is no practical way to correct these problems in household water supplies. Metallic tastes, such as those due to soluble iron, may be eliminated by ion exchange or precipitation. A common method of removing taste and odor caused by organic matter is chlorination followed by activated carbon filter. Chlorination alters the taste producing organic matter and activated carbon serves to remove it. The activated carbon also removes the excess chlorine present.

IMPURE WATER

Well water contamination is becoming a very serious threat throughout the country today. Articles are currently appearing in leading magazines and newspapers proclaiming this to the public. We must face the fact that perhaps our well waters are not safe for drinking.

A well that has been used for years does not mean that it is safe today. A well can become infected in many ways and this can happen overnight, so it is best to protect it at all times. Water that is not continuously treated has no safeguard whenever disease organisms enter the system.

When we speak of contaminated water in referring to the sanitary quality of the water, we mean water containing sewage waste. These sewage wastes enter the well from the contaminated ground water. When an individual is informed that his water is contaminated, it is difficult for him to understand because he may have been drinking the water for some time. Actually he can drink water contaminated with sewage and be exposed to only the diseases that the people had whose sewage is contaminating his water.

Most untreated water supplies have periods when they are free from water born disease, but other periods when they show sewage contamination. It is this lack of dependable safe water in an untreated water system that has resulted in over 98% of all municipalities in our country chlorinating their water. In other words, for complete protection it can be assumed that the continuous sanitary quality of each water system is not assured unless a proper amount of chlorine is kept in it automatically.

Bacteria are tiny living organisms about 1/25 thousandths of an inch in size. They are relatively easy to kill with chlorine. Not all bacteria are harmful, but even then they serve no useful purpose in the home water supply system. Examples of water born disease are: typhoid fever, cholera, and dysentery.

A virus is a minute living organism smaller than a bacteria. Much research work has been done on virus, but present information indicates that it takes from 4 to 6 times as much chlorine to kill virus as it does bacteria. Examples of virus diseases are: polio, jaundice (infectious hepatitis, one of the most prevalent contagious diseases in our country today).

Cysts are crustaceans somewhat like tiny shell fish. An amoeba forms a hard shell, called a cyst, around itself when it is in unfavorable surroundings. When it is taken into a warm body, it comes out of its shell form and enters the human system. Cysts are much larger than bacteria and can be filtered by certain kinds of fine filters. To kill cysts, a higher than normal chlorine residue must be maintained. The common water born disease transmitted by the cyst is amoebic dysentery, a serious disease for which there is to date, no universal cure.

In cases of both the shallow and deep wells the water originally comes from the earth's surface. It reaches the water table through cracks in the earth, septic tank tile fields, excavations, rock outcroppings, abandoned wells, sink holes, tree roots, animal borings and percolation through the ground. The water comes directly from rain on the earth's surface, or from lakes, rivers, ponds, etc. As water travels these routes to the water table, it carries with it whatever bacteria, virus and cysts it picks up. Little is known whether this ground filtration is of any value where virus is concerned.

Generally shallow dug wells are the least satisfactory from a sanitary and water quality standpoint. Because water in rock travels for great distances with no ground filtration, wells in rock water are generally very poor health risks. Some people say their wells are in solid rock, but if the rock were solid, it would have no water in it. Actually water bearing rock has thousands of small cracks and solution channels that act as tiny pipelines which can carry contamination for miles from where it enters the rock water to any one of the previously mentioned paths to the water table.

A water supply is safe for drinking only if it has been checked by the state or local board of health.

Unfortunately there is no simple method of testing for bacteria like you would test for iron or hardness. To confirm the presence of disease organisms is a long and costly laboratory process and in some cases, such as hepatitis virus, the organism can't be isolated at all! Therefore, a simpler indicator laboratory test has been devised. This test takes from 24 to 48 hours to perform.

The principle of this test is based on the fact that human and warm blooded animals grow in their intestines a family of bacteria called coliform bacteria. These organisms are usually harmless, but are relatively easy and inexpensive to test for. Since coliform bacteria are present in human and animal excrement only, whenever a sample of water shows a presence of coliform, the water is immediately assumed to contain human sewage and is therefore declared unsafe for human consumption.

In water testing, the frequency of tests is of extreme importance. Unfortunately, well water testing for private systems is very seldom on a regular basis. In the vast majority of cases, only one sample is taken and if it comes back safe, no tests are ever run again! In many instances, this one test is made on a new well (chlorinated just before by the well driller, but the well has not yet had an opportunity to become developed). Unfortunately water testing indicates the safety of the submitted sample only and gives no guarantee of the safety of the water 5 minutes, 5 days, or 5 months later! Well water should be tested

at least once a year for bacteria.

HOW TO CORRECT IMPURE WATER

Continuous protection from water born disease when it enters a water system is an absolute necessity. These three items: proper location, proper construction, and proper automatic chlorination will assure safe water continuously.

A water source should be located as far away from all sources of contamination as possible. It is impossible to establish arbitrary distances from farm yards, septic sewage, contaminated streams, and so forth. In one area a fine sandy soil 50 ft. may be enough; in another area of rock wells, 5,000 ft. may not be enough.

Every water source should be constructed in the best possible manner. Many books, regulations, and instructions leaflets are in existence covering this important phase. We will not go into detail here, but only wish to emphasize the importance of following accepted construction standards for safe-guarding the water source.

It is obvious that the sanitary quality of the water in a water system is dependent upon the quality of the water at its source. Thus, if the water table or other source becomes contaminated, location and construction will not make the water safe. Therefore, a third important safeguard must always be present: chlorine. By maintaining the proper amount of chlorine in the water system automatically, water born bacteria and virus will be killed. In most wells chlorine is injected by positive displacement feed pumps, called chlorinators.

In many areas it is impossible or undesirable to drill for water. These areas are therefore turning to the use of surface supplies as a source of domestic water. For all practical purposes every one of these sources can be considered unsafe without proper continuous disinfection. Some people are using this water for all household purposes except drinking and are not disinfecting the water. This is an unsafe practice because there is always the danger that the contaminated water will inadvertently be consumed. To treat surface waters, large amounts of chlorine are usually fed, then a carbon filter follows to eliminate the objectionable chlorine taste.

THE WATER SOFTENER

a) How it operates.

Previously we have discussed the water hardness problem and mentioned the equipment needed to solve this problem. In this section we shall describe how a water softener operates from a chemical standpoint. Basically, a water softener contains a mineral which is able to change hard water into soft water. First, then let us discuss this mineral. To do this, a brief look into ion exchange is necessary.

b) What is an ion?

All things, whether living or non-living, whether gas, solid or liquid, are made up of minute particles known as ions. These are attracted to each other electrically, forming atoms. Atoms differ in the number of particles they contain, in size and in weight. These atoms, in turn, combine a vast variety of proportions and types to form larger units, called molecules.

The distinctive feature of a molecule is that it consists of the smallest group of atoms by which we can identify the specific substance. Thus, a molecule of salt, which is composed of a sodium atom and chlorine atom, is no longer salt, it is broken down into sodium and chlorine. The molecule is held together by electrical attraction.

Many substances whose atoms are held together by ionic forces have a characteristic way of reacting, called ionization, when they are dissolved in water. The water separates the molecule into its component ions. Those ions which have positive electrostatic charges are called cations. Those having a negative charge are called anions.

A quick summary before describing the actual ion exchange process: All substances are composed of distinctive molecules which, in turn, are made up of characteristic quantities and types of atoms. Atoms are composed of ions. In certain substances the molecules are held together because of an attraction between positively and negatively charged atoms or groups of atoms. Many of these substances ionize (break down into cations and anions) when they are placed in water.

The fact that some substances ionize in water is a key to softening water by ion exchange. We have seen that there are some ions in water, particularly calcium and magnesium, that present costly and troublesome problems in laundry operations. The most efficient and practical way of solving these problems is to remove these ions before they can do their damage. Ion exchange performs this chore.

c) Ion exchange.

Ion exchange in water conditioning is the process of removing calcium and magnesium, the hardness producing ions, and the substitution of sodium, an unobjectionable ion, in their place.

Remember then, it is an exchange. Since these ions are positively charged, or cation, the mineral is a cation exchanger. During the exchange, two sodium ions are released for each calcium or magnesium received. This is because each calcium or magnesium ion has a charge of 2, whereas sodium has only a charge of 1. The balance must be maintained.

The transaction takes place because the exchanger attracts the new ions more strongly than the ions it already holds. The new ions can, therefore, displace the original ion from the exchanger and occupy the site they vacate.

While the "zeolite" family of ion exchange substances are found in nature, it is more economical to use man-made materials of higher exchange values. These ion exchange materials are a fine, bead-like appearing balls about the size of a pin head and they are quite porous. They are manufactured from various petroleum bi-products by special processes. It is organic in nature.

d) Regeneration.
A resin can carry out millions of transactions simultaneously over long periods before its supply of sodium ions must be replenished. When the exchanger can no longer produce soft water, the exchanger is considered exhausted. Fortunately, the absorption capacity is only temporarily lost. It is replaced by regeneration.

Regeneration is basically a reversal of the absorption process. It means the restoration of the original capacity of the softener to again soften hard water after the original capacity has all been used. It is somewhat the same as refilling the gas tank of an engine when it is empty, otherwise it would not run. The life of a good softener is many years.

Regeneration is accomplished by treating the exchanger with a concentrated solution of the sodium ions, in the form of common salt, sodium chloride, NaCl. This releases the calcium and magnesium ions which are discarded to the drain.

Regeneration therefore renews the ion absorption powers of the exchange material and permits the exchanger to be reused for virtually countless absorption cycles. An important fact to remember is that ½ pound of salt is required for each 1,000 grains of hardness exchange. This means that if a softener is rated at 20,000 grain capacity, 10 lbs. of salt are needed to regenerate.

OPERATION OF SOFTENERS IN GENERAL

In the normal course of softening water the mechanics of operation are much the same regardless of whether the unit is fully automatic, semi-automatic or manually operated. The unsoftened water enters the top of the mineral tank and flows downward through the mineral — the result is zero soft water, for which the units were designed to deliver.

As the water flows downward through the softener tank the mineral performs two duties. One is to act as a filter and catch any debris from the hard water and the other is to soften the water. The first step in regeneration is then to backwash the mineral, for a matter of some ten minutes, to loosen deposits and flow them to the drain. At the completion of the backwash, the salt or brine is added and a slow rinse of approximately sixty minutes duration, will bring the mineral back to its original state.

Whether this process is done automatically, semi-automatically or manually depends on the type of softener selected. The fully automatic is becoming very popular since it is not only completely satisfactory but is also a good-looking, streamlined and inexpensive addition to any home. Fire-cured Epoxy coated steel tanks now carry a ten year warranty.

a) The Fully Automatic Softener.
Figure 51 shows the fully automatic softener which requires no personal attention except to add salt to the brine tank occasionally. The rugged, adjustable timer and valve does the regeneration, automatically, while you sleep. The regen-

Fully Automatic Softener
Fig. 51

eration timer can be set to function on intervals of 1, 2, 3 or 6 day cycles, depending on the water make-up and customer requirements. Exclusive valve design maintains proper regeneration for any water pressures between 20 and 125 psi when correctly installed.

The polyethylene brine tank eliminates corrosion and salt deposits. The storage capacity is 300 pounds of No. 2 rock salt, do not use any other type of salt.

b) The Automatic Softener

Figure 52 shows the Automatic Softener which requires only a minimum of attention to keep operating properly and delivering filtered, softened, crystal clear water. It incorporates almost all of the quality features of the 2 cycle fully automatic unit. In tank size, mineral quantity, capacity and salt storage brining system, it is identical.

The difference between fully automatic and automatic equipment lies in the timing device to start and control regeneration.

An electric timer will regenerate a fully automatic softener on a predetermined schedule. An Automatic Softener leaves the **starting** of regeneration to the user — the simple turning of a switch. All other regeneration processes are automatic.

c) The Manual Softener

Figure 53 shows the manual softener which contains more ion exchange mineral in the tank than the fully automatic or automatic softener. This lengthens out the regeneration periods for the convenience of the owner.

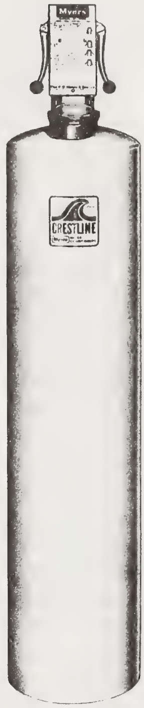
Even though the water may still be soft at the end of thirty days, the softener must be regenerated a minimum of once each month. If the water is dirty or contains suspended particles the softener should be backwashed every 7 to 14 days, even though regeneration may not be necessary at that time. This prevents fouling of the mineral bed. If too dirty, a filter should be installed ahead of the softener.

Just one of the outstanding features of this softener would be the Safety Tank Cap which cannot be removed while the unit is in service or when any pressure exists in the mineral tank. This prevents messy conditions experienced by users of other equipment.

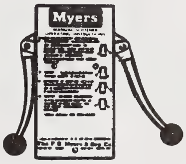
Another feature is the time-proven valve assembly. Here is a rugged, all bronze valve with a minimum of movable parts and designed to keep any pressure drop to an absolute minimum.

The procedure to backwash and regenerate is as follows:

Automatic Softener
Fig. 52



Manual Softener
Fig. 53



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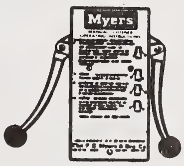

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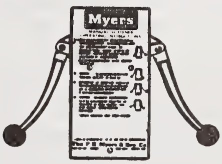
To Backwash and Regenerate —

1. **BACKWASH:** Pull right lever up. Allow softener to backwash a minimum of 10 minutes or until water runs clear at drain. Return right lever to down position.
2. **RINSE:** Pull left lever up. Allow a 5 min. rinse.
3. **SALT:** Pull both levers up. Remove tank cap. Pour in .... lbs. of PELLET salt. Replace tank cap.
4. **RINSE:** Return right lever to down position. Rinse for 60 minutes. Return left lever to down position.

Softener is now in Service.



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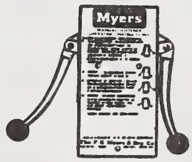

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It is important to note that all softeners are designed to provide adequate water even during the regeneration period. All carry the S-100 Gold Seal of the industry standard, which qualifies such softeners for F.H.A. loans.

SALT FOR REGENERATING THE SOFTENER

The salt used in regenerating water softeners is an important factor in the successful operation of the softener. It is fortunate that salt is used for this purpose since it is one of the earth's commonest minerals.

Just any salt dare not be used in a water softener; that is, if the softener is expected to give the desirable results it is intended to produce. Many commercial grades of salt contain a large amount of dirt and insoluble material. Only salt regenerates a softener, not the dirt and stones from salts containing them. The dirt in salt will cause trouble in a water softener. In a brine tank this insoluble material will build up a sludge in the tank and may foul up the brine injection.

There are really only two kinds of salt. Evaporated salt and rock salt. Evaporated salt is made from brine of two kinds: surface brine and brine from wells. Both evaporated salt and rock salt may be produced from the same rock salt deposit. Rock salt comes from underground in large lumps, which are crushed, screened and graded to the various commercial sizes needed. All evaporated salt is refined salt. Flake salt is a type of evaporated salt.

DO THIS:

1. With all single tank water softeners of the internal salting type, use nothing but evaporated salt (nugget or pellet) for best all round results.
2. Use only No. 2 rock salt, in any water softener with brine tank, salt tank or brine saturator.

NEVER DO THIS:

1. Never, never, use stock salt, ice cream salt, or any salts obtained in gunny sacks. Remember, you want salt, as nearly pure as possible, not dirt and sand as well.

The question sometimes arises as to what harmful effects salt will have in a septic tank. Here is what the Water Conditioning Foundation says:

"Brine from the regeneration of a household water softener may be safely discharged into the average septic tank. Organic matter in septic tanks is converted by bacterial action into water soluble products. Bacterialogists tell us that salt in low concentrations is not harmful to bacterial growth in action. In fact, salt has been added to culture media for favoring a growth of bacteria. High concentration of salt, however, might inhibit this growth. That condition is the basis for the statement made by others that salt brine should not be discharged into septic tanks. The question then becomes that of estimating the concentration of salt that may result from discharge of brine into the tank.

"Septic tanks vary in size. Many states require a minimum of 500 gallons. A small one holds 300 gallons of fluids or about 2500 lbs. The salt used for regeneration of the softener may amount to 50 lbs. which would produce a 2% solution in the small septic tank, if no water were added at the same time. About 150 gallons of water would be used for brining and rinsing the salt from the softener. The resulting low concentration of salt would have no effect on bacteria activity.

QUICK REFERENCE TABLE OF WATER PROBLEMS AND SOLUTIONS

Impurities	Problem	Remedy
Hardness (Calcium & Magnesium)	Scale in pipes and water heaters. Causes insoluble soap curd on dishes and fabrics.	Removal by ion exchange water softener.
Iron	Discolors waters, stains plumbing fixtures and fabrics, causes deposits in heaters.	Removal by a softener or by an iron filter when large amounts are present. Also removed by Chlorination then filtration.
Acid water (low pH)	Corrosion, attacks piping & tanks, red stains from galvanized pipe, blue green stains from copper.	pH raised by Neutralizing filter or by soda ash food.
Hydrogen Sulphide	Taste and odor, tarnishes silverware.	Removal by oxidizing filters or chlorination and then filtration.
Mud, Clay, Silt (dirty water)	Suspended matter in water cloudy, dirty water.	Sand Filter
Taste & odors (organic matter)	Makes water unpalatable.	Carbon Filters — In some cases chlorination and then filtration.
Sodium salts	Salty or alkali taste.	Cannot be economically treated.
Bacteria	Source of disease, unfit for human consumption.	Chlorination and Filtration.
Algae	Taste, odor, color.	Chlorination and Filtration.

"A proof of this conclusion is that there are thousands of water softeners which discharge salt into household septic tanks and as far as we know, no trouble has ever been reported. It may be added that if bacteria action were slackened by the salt, it would become quite normal again after the day's discharge of solids and fluids from the household."

WATER FOR IRRIGATION

Ion exchange softened water is not recommended for watering lawns, gardens or flowers.

Most growing plants require special soil conditions for healthy and thrifty growth. Many flowering plants demand slightly acid soil or they wither and die. Others are quite susceptible to high concentrations of soluble salt in the soil water. Common salt, for example, kills most grass.

Softened water carries only sodium salt. The average sprinkling of flowers, garden or lawn wets but an inch or two of the soil. Much of the water is lost by evaporation. This leaves the sodium salts in the soil. After several successive waterings, there may be accumulated a sufficient amount of sodium salt in the soil to retard the growth of the plant.

Therefore, the use of softened water is not recommended for irrigation. A by-pass or separate line carrying raw or hard water should be provided for this purpose.

FILTERS

Webster defines a filter as "a device for separating solid particles, impurities, etc. from a fluid by passing it through a porous substance such as sand, charcoal, etc." These filters supplement the water softener line and, outward appearance-wise, they are identical with softeners. Their purposes are to remove iron and sulphur, to increase pH values, removal of visible dirt or suspended matter and removal of disagreeable tastes and odors.

a) The Iron Filter.

An iron filter, Figure 54, is designed to remove inorganic iron, ferrous and ferric, and sulphur from water. This is accomplished by oxidizing all the iron to the ferric or insoluble state and then filtering this iron out. The mineral called manganese zeolite is a substance that will do this.

Manganese zeolite, a black material, is made from processed green sand zeolite. Green sand zeolite is made by refining and stabilizing mined, so-called green sand.

Manganese zeolite is primarily used for the

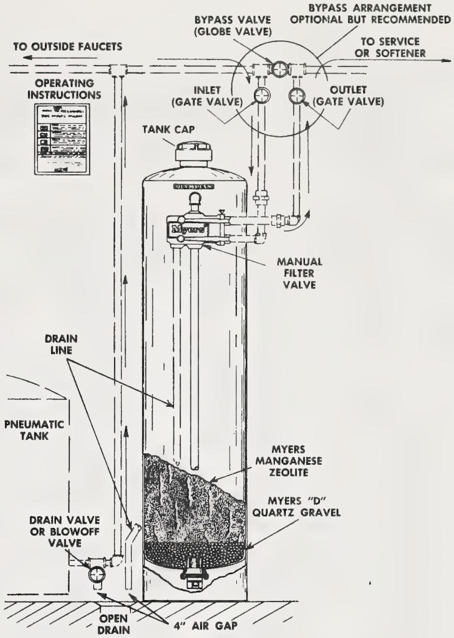


Fig. 54 — Iron Filter

removal of iron and manganese from water, and to a lesser extent the removal of hydrogen sulphide. Upon passage of water containing iron or manganese in ferrous or manganous states (in solution — in other words, invisible) through a bed of manganese zeolite, oxidation of the iron and manganese to the ferric and manganic state (insoluble—precipitated—visible) occurs. These insoluble oxides are precipitated out and filtered in the bed of manganese zeolite. They must be removed by frequent backwashings. When the oxidized capacity of the bed is diminished, the manganese zeolite is regenerated with potassium permanganate and rinsed free of potassium compounds. In this way, available oxygen is once again restored within the bed of manganese zeolite, and the filter is ready to resume its task of iron, manganese, or sulphur removal.

In operation, the water passes down through the manganese zeolite which oxidizes the iron and then filters it. When it is time to regenerate, the first step is to backwash which is a reversal of flow of water through the tank. This removes the iron and dirt which has collected on top of the bed. Frequent backwashing is necessary. When the zeolite is exhausted, it must be regenerated with potassium permanganate which is, in turn, reduced as it gives up oxygen to the manganese zeolite.

Potassium permanganate is placed in the tank and the unit slowly rinsed down-flow. This chemical recharges the mineral with oxygen, in a similar manner as salt recharges a softener.

DO THIS:

1. Backwash and rinse filter every week (without fail).
2. Charge each month or week for iron removal as required.

Manganese zeolite lasts indefinitely—for years. What destroys it is misapplication, misuse, and abuse. It has definite limits of application of utmost importance. Here are some of the musts to prevent its misuse:

1. Low pH — below 6.8 — indicates the free carbon dioxide content of the water is high. It must first be neutralized by a neutralizer or by soda ash fed with a solution feed pump ahead of the iron filter, to prevent manganese being picked up from an exhausted bed of manganese zeolite.
2. Maximum iron or manganese in raw water should not exceed 10 ppm.
3. Maximum flow rate in gallons per minute should not exceed 3 gpm per square foot cross section bed area.
4. Proper backwash rate of 8 gpm per square foot per cross sectional bed area is needed to clean the manganese zeolite of the precipitated iron and manganese oxides.
5. Sufficient contact time is needed between the potassium permanganate solution and the manganese zeolite to restore available oxygen. Don't shorten the slow rinse time required, below that designated in the operating instructions.

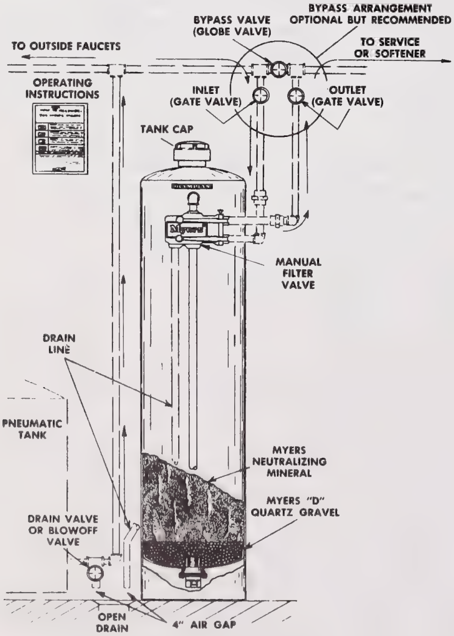


Fig. 55 — Neutralizing Filter

This iron filter, then, is designed to remove the inorganic iron. If organic or iron bacteria are present, chlorination is necessary.

b) The Neutralizing Filter.

The purpose of a neutralizing filter is to:

1. Increase pH value of water.
2. Neutralize free carbon dioxide.
3. Decrease corrosion.
4. Add alkalinity.
5. Remove dirt (turbidity and suspended matter).

In the section covering corrosion, we said that the presence of large amounts of free carbon dioxide gas in solution in water often renders the water acid in character. These waters are corrosive to iron, galvanized pipe, brass and even copper pipe. Generally, the corrosion is much greater on hot water piping and tank.

Neutralizers, Figure 55, have been designed to combat this expensive corrosion. The tank is filled with a crushed and very carefully graded limestone of a pure type. The carbon dioxide will be neutralized and pH will automatically raise to 7.0 or 7.3 at which pH the action ceases.

A neutralier requires backwashing occasionally to loosen the material. Pay particular attention to the backwash rate and flow rate as given on the instruction card. Since the material is heavy, fairly high backwash rates are required to clean the bed. The flow rate is low because retention time is necessary for the above reaction to take place. It is sometimes necessary to use two neutralizers hooked in parallel to provide proper flow rate.

Some of the material is dissolved and it should be checked and the proper amount added each year. Since a small amount of limestone is dissolved in the water to neutralize the pH, the hardness will increase slightly. The disadvantage of this increase in hardness is overcome by a water softener installed following the neutralizer.

The neutralizing filter automatically raises the pH of the water and reduces the corrosiveness. In appearance, it is very similar to that of a water softener. It requires only occasional backwashing and the addition of a small amount of neutralizing material each year.

c) The Sand Filter.

A sand filter, Figure 56, is for the physical removal, by simple filtration, of visible dirt or suspended matter from water — due to silt, sand, organic matter, and rust particles, commonly known as turbidity.

Some waters are clean most of the time, but occasionally become quite muddy or turbid, par-

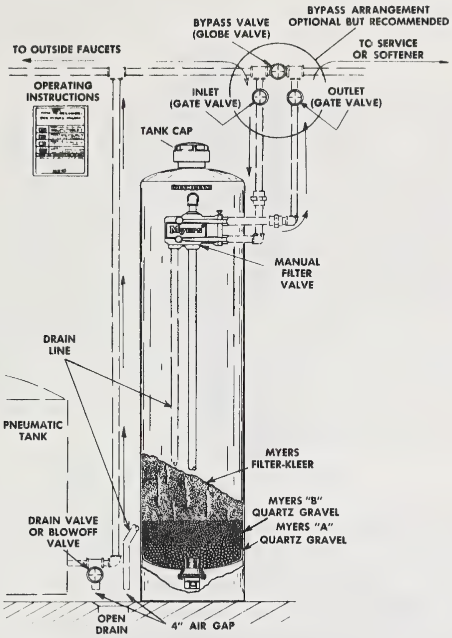


Fig. 56 — Sand Filter

ticularly at the ends of the city mains when something happens to rile the water such as large demands for water. Surface waters from lakes or rivers may be turbid most of the time. A sand filter will remove all suspended matter not in solution and make the water sparkling clean.

The sand filter is not for the purpose of removing iron that is in suspension causing the water to turn brown. If iron is in solution, it can be removed by means of a water softener or iron filter. The filter should be backwashed on the average of once a week to remove the accumulation of dirt and to keep the filter bed clear.

Whenever the dirt, turbidity, suspended matter, or discoloration in a water supply is not easily settled out or filtered, an alum feeder should be installed in the line ahead of the filter.

Alum reacts with the natural alkalinity in the water to form gelatinous precipitates which absorb or enmesh impurities, resulting in course particles known as the floc. This floc with its absorbed impurities is then more easily removed by filtration.

A polyphosphate feeder jug can be used as an alum feeder. In place of polyphosphate, alum is used. The alum used must be either pot-ash alum or ammonium alum in lump form.

The restrictor valve on the alum pot is set at an angle of approximately 15 degrees from the horizontal. The inlet and outlet valves must be wide open at all times. As the water enters, a small portion of the stream is diverted up through the pot containing alum in lump form. The amount of water shunted through the pot dissolves a little of the alum and carries it back into the main stream through the center pipe in the pot.

After each backwashing and rinsing, just before returning the filter to service, the chemical feed pot must be checked and the necessary amount of alum added. Alum is added to the chemical feed pot after filters are backwashed and while rinsing, prior to returning the filter to service. The amount used is determined by trial and error, but approximately 1 to 3 pounds depending on size of filter or filters.

Sometimes it is necessary to feed sal soda to the water to make up for alkalinity deficiency caused by the use of alum in a recirculating system. If this is necessary, use lump sal soda, in the chemical feed pot or feed soda ash by a liquid feed pump.

d) The Carbon Filter.

The carbon filter, Figure 57, removes unpleasant taste and disagreeable odor due to chlorine, industrial waste and organic matter. Certain water supplies have unpleasant taste and odors. Among such waters are those which are chlorinated for bacteriological protection. Likewise, objectionable fishy and marshy tastes are often encountered. Such tastes and odors can be eliminated

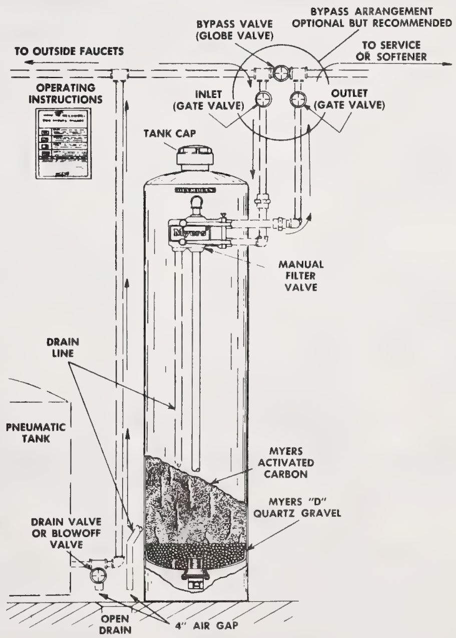


Fig. 57 — Carbon Filter

by the carbon, (taste and odor removal filter). Only occasional backwashing is necessary — usually once or twice a month is sufficient unless the water is really bad.

Activated carbon literally absorbs great quantities of taste and odor producing impurities from water. This material has unusual hardness and durability, fine grain porosity, and high activation for maximum taste and odor removal. it is manufactured from selected northern hardwoods consiting of a blend of maple, beech and birch woods.

In the filter, the carbon is supported on a bed of "D" size quartz gravel.

Since the carbon actually absorbs the unpleasant tastes and odors, it cannot be regenerated or renewed. The occasional backwashing which is necessary is to remove the suspended dirt from the mineral. When the carbon has absorbed all the taste and odors that it can hold, it must be replaced. The period of time which carbon will last, for an average household, is estimated at between 1 and 3 years. This length of time is dependent upon the intensity and kind of taste and odor removed, as well as the quantity of water which has been conditioned.

FILTER SELECTION CHART

PROBLEM			TREATMENT*	
pH (corrosion) Control	6.6 to 7.0	Jug Feeder (Polyphosphate)	Neutralizer	Water Guard Feeder (Soda Ash)
	5.5 to 6.8		Neutralizer	Water Guard Feeder (Soda Ash)
	4.0 to 6.8			Water Guard Feeder (Soda Ash)
	below 4.0	Treatment Not Practical		
Iron (red water) Control	0.2 ppm to 3.0 ppm (clear when drawn)	Jug Feeder (Polyphosphate) and/or Water Softener	Iron Filter	Water Guard Feeder & Sand Filter (Chlorine)
	0.3 to 10.0		Iron Filter	Water Guard Feeder & Sand Filter (Chlorine)
	0.3 to 25.0			Water Guard Feeder & Sand Filter (Chlorine)
	Over 25.0	Treatment Not Practical		
Hydrogen Sulphide (Rotten egg odor) Sulphur	Up to 5 ppm	Sulphur Filter	Water Guard Feeder & Sand Filter (Chlorine)	
	Up to 15 ppm		Water Guard Feeder & Sand Filter (Chlorine)	
	Over 15 ppm	Treatment Not Practical		
Turbidity (Visible dirt)	Coarse Sediment	Sand Filter		
	Fine Sediment	Jug Feeder (Alum) and Sand Filter		
Taste & Odor	Chlorine, organic, musty, etc.	Carbon Filter		
	Brackish or salty	Treatment Not Practical		
Bacteria	Health Dept. Tests Show Pollution	Water Guard Feeder (Chlorine)		

Note: Estimate service flow and select largest size that can be backwashed with pump capacity available.
*Use only one type of treatment when more than one is listed.

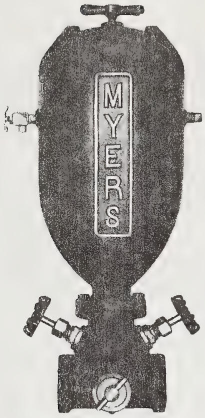


Fig. 58 — Polyphosphate Feeder

THE POLYPHOSPHATE FEEDER

Polyphosphate feeders, Figure 58, and polyphosphates are designed to retard corrosion, to eliminate red water, to help prevent lime scale, and are for use with all water systems and pumps everywhere, and on city waters, too.

Without a question of doubt, corrosion is and always has been the greatest problem of all — how to keep from wearing out pipes, utensils, appliances, etc., in other words. Corrosion cannot be stopped, but it can be retarded or inhibited to lengthen the service of the product.

Polyphosphate treatment inhibits corrosion by the absorption of the microscopically thin film of this dissolved substance on the surface of the metal in contact with the flow of water. This treatment minimizes the attack and reduces the corrosion to eliminate the problem. The only requirement is that the polyphosphate treatment be sufficiently applied to create and maintain the film. The treatment must be continuous.

The effective limits of polyphosphate treatment for corrosion prevention may be considered. The so-called threshold treatment of 1 to 10 ppm has long been accepted as an effective means of control of both incrustation and general corrosion in cold water lines, the minimum degree of treatment varying with the composition of the water. Soluble iron in such a supply can be sequestered and its oxidation retarded or even prevented. It is also accepted that there must be between 5 and 10 ppm of polyphosphate in cold water and 5 to 20 ppm in hot water to give protection against the corrosive tendency of a water. One pound in 12,000 gallons is approximately 10 ppm.

The greatest benefits are obtained by placing the feeder between the pump and the pressure tank, see Figure 59. When the pump suction tube of the polyphosphate feeder is hooked up to the inlet of the pump, the protection of both the pump and the pressure tank can then be afforded.

It should be noted that the rate of solubility of the polyphosphate is affected by the hardness of the water.The greater the hardness, the lower is the rate of solubility. The primary rate of solubility depends, of course, on the surface provided by the particle size of the polyphosphate in the feeder.

The temperature of the water at the point of treatment is critical. The rate of solubility is greatly increased by only a slight increase in temperature. Therefore the correct Myers Polyphosphate, either the MP21 or MP51, must be selected depending upon the temperature of the water.

Polyphosphate is not a water softener. Where the water is hard and the hardness is a nuisance, the water should be softened with a water sof-

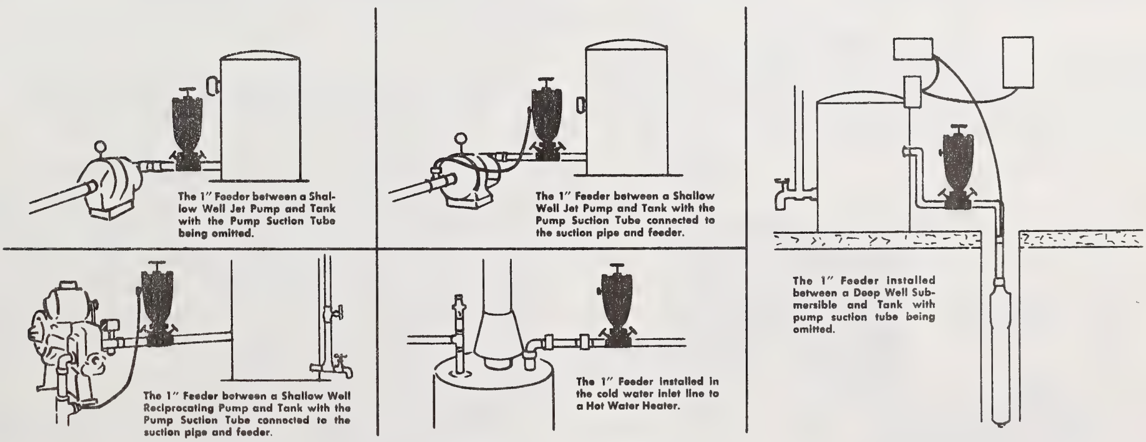


Fig. 59 — Feeder Installation

tener. The polyphosphate treatment does not prevent the curdling of soap with the hardness of the water. Neither does it change the composition or pH value of the water.

Polyphosphate does not remove iron. The feeder does not act as a filter. It can prevent red water if used intelligently. Its use is effective because the polyphosphate sequesters or ties up the dissolved iron in the water to keep it from becoming oxidized. But remember, the iron must be in solution as it enters the feeder. Once oxidized, the iron will precipitate out of solution and turn the water red. Once this has happened, the polyphosphate treatment will not prevent red water or red stains.

Water with iron as low as 0.25 ppm will often cause discoloration overnight from a dripping faucet. Iron in excess of 0.5 ppm is usually troublesome. A polyphosphate feeder is the answer. For the removal of hardness and low amount of iron in solution, a softener is recommended. If over 2 or 3 ppm of iron, supplementary iron removal equipment is necessary.

The polyphosphate feeder is installed directly in the line between the pump and tank or from the line coming from the pressure tank. Part of the water is deflected up through the polyphosphate into the jug which will slowly dissolve some of the substance and feed back into the line. The amount of water deflected up into the jug is controlled by a flapper valve installed in the base of the feeder. Small amounts of polyphosphate are dissolved and the feeder should be checked each month and a small amount added.

In addition to the polyphosphate feeder, polyphosphates can be added to water by means of a liquid chemical feed pump.

CHLORINATION

Pollution of water supplies is an ever increasing problem. Almost daily we read about this threat in local papers and national magazines. Fortunately something can be done about this enemy within and the corrective measures are inexpensive.

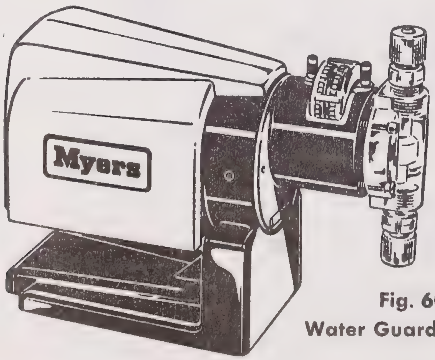


Fig. 60
Water Guard Feeder

The answer is to simply add the proper amount of chlorine to the water supply, to assure adequate contact time between the chlorine and water, and to chlorinate in excess of the necessary amount in order to always leave a residual of chlorine in the water. That portion of the chlorine dosage not used up by the chlorine demand is known as the preavailable chlorine residual.

It is necessary to chlorinate in excess of the actual amount immediately needed to provide assurance that the water is safe and will continue to be safe. The reasons are: 1) It is a means of controlling the chlorine dosage. 2) It represents the only immediate proof that the water is safe. 3) It is a protective barrier against further contamination.

Generally, 0.2 ppm of chlorine residual is considered as safe for drinking water and 0.5 ppm satisfactory for swimming pools. However, it is suggested that all dealers secure copies of their local and state codes before proceeding, should such codes exist, since some requirements will vary state-by-state.

Once the water supply is adequately chlorinated, and the residual established, the owner needs some easy method of checking this residual or else he has no guarantee of continued safety. The common and inexpensive method is the use of the orthotolodine color test which is based on color comparisons.

Although hypochlorination can be handled either manually or automatically, the manual method is more difficult and is not readily accepted by the codes. We shall discuss only the automatic process, by the positive feeder, which definitely meters the correct amount of injected chlorine. The positive feeder can be installed in various ways and will handle different solutions, as we shall see later.

The Myers Water Guard Feeder, Figure 60, delivers low cost, positive chemical treatment for drinking water. Each suction stroke draws a precise amount of the treating chemical into the feeder head. On the discharge stroke, the treating chemical is injected in a prescribed amount, into the main water supply line or well, Figure 61. Thus the water treatment is positive and eliminates the possibility of errors.

Designed for water sterilization, for taste and odor control and for the elimination of red water, the features are:

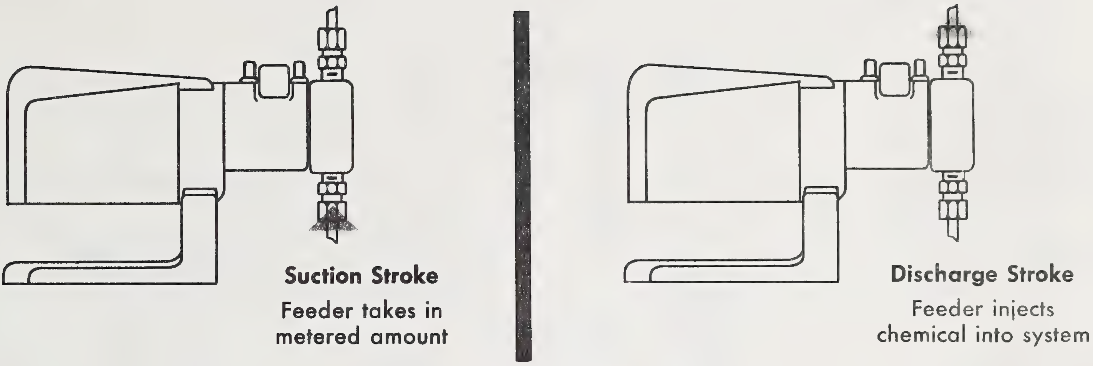


Fig. 61 — Operation of Feeder

a) Can be installed on any private water supply system.
b) Mounts anywhere — on floor, shelf or wall.
c) Can be adjusted while in operation.
d) Positive action valve for foolproof water treatment.
e) Corrosion-proof for long life.
f) Purifies your water supply efficiently, economically.

Installation and Initial Feed.

A contact time after chlorination of 20 minutes is desirable to insure safe water. Usually the pressure tank will provide necessary retention time. The size of tank necessary is 20 times the GPM pump capacity, plus 25%. If pressure tank is not large enough, a separate retention tank is needed. This could be provided by a softener if one is needed. See Figure 62.

Usually a chlorine feed of 1 ppm is enough to purify well water. This will require 6 oz. of household bleach, Figure 63, mixed with 10 gallons of water for every 100 gallons per hour of pump capacity. For example, if pump capacity is 300 gph, mix 6 × 3 or 18 oz. of bleach with 10 gallons of water.

Checking and Adjusting Chlorine Feed.

a) If chlorine residual is less than 0.2 ppm, add more bleach to solution.
b) If chlorine residual is above 0.5 ppm, add water to dilute solution.
c) When correct residual is obtained, mix future batches accordingly.
d) Check cold water for chlorine residual regularly.

Bacteriological Test.

Your State Board of Health will make a bacteriological test of your water at no cost. They are prepared to do this under controlled conditions. Do not send a water sample to the F. E. Myers & Bro. Co. for such a test. The Board of Health will make recommendation, based on their analysis, which may include chlorination to assure safe water.

Iron Removal By Chlorination and Filtration.

Iron in solution can normally be removed by chlorination and filtration. Chlorine is an excellent oxidizing agent and when fed into the water supply will oxidize and precipitate the iron. This oxidized iron can then be removed by filtration. This filtration can be accomplished by a standard sand filter. See Figure 64.

In addition to oxidizing the iron in solution, chlorine will also destroy the iron bacteria. These bacteria are plant-like growths that feed on the pump, pipes, etc., causing damage as well as building up slime in the toilet water closets, etc. Iron bacteria cannot be removed by filtration alone.

If water is acidic (pH below 7) the pH must first be raised to neutral. Iron will not readily oxidize in acid water. Soda ash can be mixed and fed with the chlorine solution from the same container.

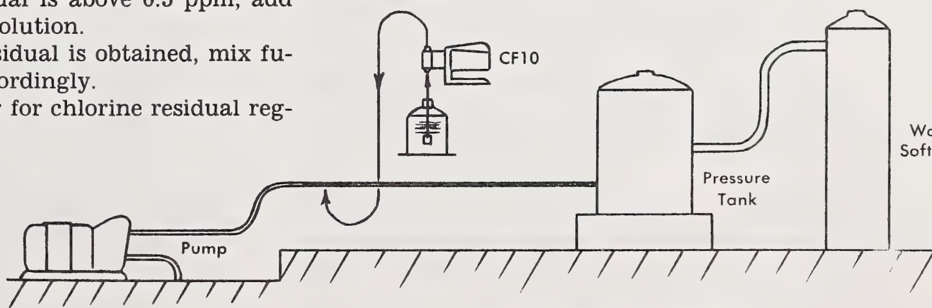
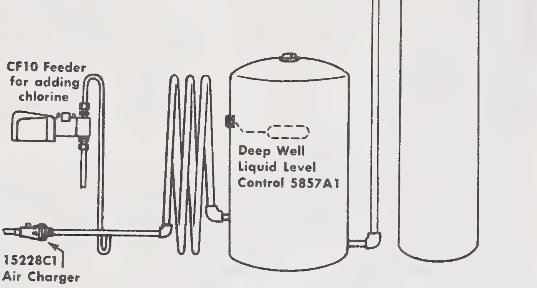


Fig. 62 — Feeder Application

Fig. 63



Fully automatic filter with
air charger and chlorinator

Fig. 64

Procedure.

One ppm of chlorine will oxidize one ppm iron. Sufficient chlorine should be fed to have a residual of at least 0.2 ppm. Purification as well as iron removal will be accomplished.

To prepare a 1 ppm chlorine solution mix 6 oz. of household laundry bleach with 10 gallons of water for every 100 gph pump capacity. If residual chlorine is not 0.2 ppm, increase amount of bleach until the correct residual is maintained. Then use this amount in preparing future solutions.

Example.

Problem: 5 ppm of iron, 500 gph pump capacity.

Solution: Since 6 oz. of bleach are required for each 100 gph pump capacity, 6 × 5 equals 30 oz. for 5 ppm iron, 30 × 5 equals 150 oz., or 4 qts. and 22 oz. of ordinary bleach are required for each 10 gallons of solution.

Sulphur Removal By Chlorination and Filtration.

Sulphur can be precipitated by chlorine bleach and then filtered out by a sand filter.

Procedure.

Start with a 2 ppm chlorine feed and then increase the feed until the sulphur odor disappears and the water has a free chlorine residual of 0.5 ppm. For 2 ppm chlorine feed, mix 12 oz. of household laundry bleach with 10 gallons of water for each 100 gph pump capacity. For example, if pump capacity is 500 gph, use 12 × 5 oz. or 60 oz. of bleach in 10 gallons of water.

Iron Stabilization and Corrosion Protection With 2MP91 Polyphosphate.

Polyphosphates have been used for years to hold iron in solution, preventing it from oxidizing, precipitation and staining. Up to about 4 ppm of iron may be treated. Above 4 ppm, complete iron removal is recommended since complete stabilization may not be possible and some staining may occur at higher concentration.

For general household use, a water softener is recommended following the polyphosphate treatment to remove the stabilized iron.

2MP91 polyphosphate is also recommended for corrosion prevention in pumps, tanks and pipes. A protective film is formed on the metal surfaces by the polyphosphate.

Procedure.

For best results the polyphosphate should be fed to the water before pressure tank so that the iron is not oxidized by air in the tank. Polyphosphate will not prevent iron from staining after the iron has already been oxidized.

The polyphosphate then should be fed either into the suction of the pump or into the discharge pipe between pump and tank. See Figure 65. If fed into suction line, a No. ASV-10 Anti-Siphon Valve is required. In the case of a submersible pump, it can be fed into the well at the intake of the pump. See Figure 66.

For each ppm of iron present, 4 ppm of polyphosphate must be fed. To prepare 10 gallons of 4 ppm concentration of polyphosphate for every 100 gallon per hour of pump capacity, 1½ oz. of 2MP91 polyphosphate is required. This is based on the 50% capacity of the feed pump, preset at factory.

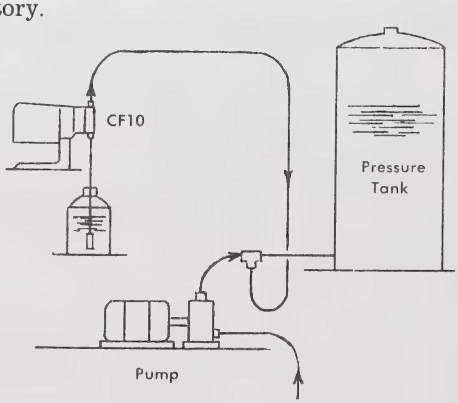


Fig. 65 — Feeding Liquid Solutions
(Jet Pump Installation)

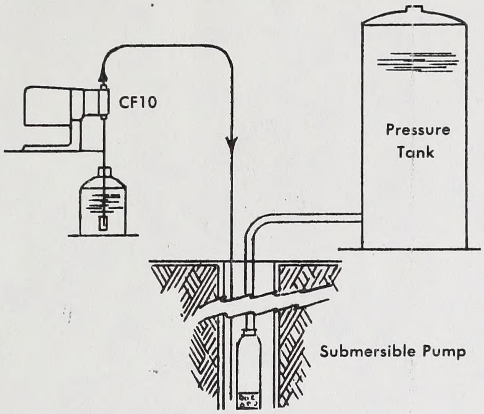


Fig. 66 — Feeding Liquid Solutions
(Submersible Pump Installation)

Example.

Problem: 3 ppm iron and 400 gph pump capacity.

Solution: Since 1½ oz. of 2MP91 polyphosphate is required for each 100 gallon pump capacity, 1½ × 4 equals 6 oz. for 1 ppm iron. Since we have 3 ppm iron, 6 × 3 equals 18 oz. of 2MP91 will be required for 10 gallons of solution.

Iron Bacteria.

Polyphosphate will not prevent staining from iron bacteria. If iron bacteria is present, feed chlorine to destroy bacteria and oxidize iron.

Neutralizing Acid Waters With Soda Ash.

Waters with a pH below 7 are acidic and tend to be corrosive. The acid water problem can be eliminated by feeding soda ash solution into the water by means of a feed pump. Soda ash is a highly alkaline compound used in water treatment by many municipalities. See Figures 65 and 66 for typical installations.

Soda ash combines chemically with the acid water to completely neutralize it. Thus the soda ash feeder can be adjusted to feed the correct amount to raise the water to whatever pH is desired.

Procedure.

Start with a 20 ppm feed. To prepare 10 gallons of 20 ppm soda ash for every 100 gph pump capacity, use 8 oz. of soda ash. If pH is not raised to 7.5, increase the amount of soda ash. The maximum amount that can be dissolved in 10 gallons of water is 10 lbs.

Soda Ash (58% light grade) can be purchased in 100 lb. bags at most chemical supply houses. If no soda ash is available, sal soda purchased at a grocery store should be used. (Because sal soda

CF10 FEEDER SOLUTION GUIDE

IRON REMOVAL

WELL PUMP RATE gph	WELL PUMP RATE gpm	Household Bleach to Mix With 10 Gallons of Water With a 50% Stroke Setting On CF10 Feed Pump For a 1 ppm. Chlorine Feed	NOTE: IRON
180	3	12 oz.	For each ppm of iron, 1 ppm of chlorine must be fed. Therefore, multiply the given figure by the number of ppm of iron. Then check chlorine residual and if not between 0.2 and 0.5 ppm, vary feed solution by adjusting strokes on feeder or by adjusting amount of bleach in feed solution.
240	4	1 lb. 2 oz.	
300	5	1 lb. 8 oz.	
360	6	1 lb. 12 oz.	
420	7	2 lb. 2 oz.	
480	8	2 lb. 6 oz.	
540	9	2 lb. 9 oz.	
600	10	3 lb. 0 oz.	
660	11	3 lb. 6 oz.	
720	12	3 lb. 12 oz.	

ACID CONTROL

WELL PUMP RATE		Soda Ash to Use With 10 Gallons of Water With a 50% Stroke Setting on CF10 Feed Pump pH Reading		NOTE: ACID
gph	gpm	Below 6.0	Above 6.0	This figure indicates starting amount. Check pH and if not 7.2 to 7.5, vary feed solution by adjusting stroke on feeder or by adjusting amount of soda ash in feed solution. If soda ash is not available, sal soda can be used but the amount used must be doubled.
180	3	1 lb. 8 oz.	1 lb.	
240	4	2 lb.	1 lb. 6 oz.	
300	5	2 lb. 10 oz.	1 lb. 12 oz.	
360	6	3 lb.	2 lb.	
420	7	3 lb. 8 oz.	2 lb. 6 oz.	
480	8	4 lb. 2 oz.	2 lb. 12 oz.	
540	9	4 lb. 8 oz.	3 lb.	
600	10	5 lb. 2 oz.	3 lb. 5 oz.	
660	11	5 lb. 8 oz.	3 lb. 12 oz.	
720	12	6 lb.	4 lb.	

is slightly less than half as strong as soda ash, all mixing quantities should be doubled.)

Feeding Chlorine Bleach Together With Soda Ash.

An important advantage of soda ash feeding is that it can be accomplished together with automatic chlorination equipment. Soda ash and chlorine bleach solution can be mixed and fed with one feed pump from same solution container.

When first starting, dissolve soda ash in 10 gallons of water and adjust solution strength so that the pH is 7.5. Then add bleach and adjust for correct residual chlorine. Then this same ratio can be used to mix future solution. Always dissolve the soda ash first and then add the bleach.

WATER NOT JUST WATER

It is sometimes difficult to explain the merits of conditioned water to those who have never experienced the ill effects of hard water or iron in water. But to those who have water problems, modern water conditioning opens up an entirely new way of life.

Since waters vary in makeup from well to well, and area to area, the first step is to have a water analysis made. The progressive water conditioning dealer has the necessary knowledge to make "on the spot" checks and furnish complete corrective equipment. In severe cases, this same dealer can also depend on the chemists of the equipment manufacturer.

Perhaps we can now conclude that water is not "just water" any more. It pays to be waterwise and know the difference.